lead things, but do contain a potency of life in them to be whose progeny they are, nay they do preserve as in a id extraction of that living intellect that bred them

—*John Milton*

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Trigeminal Neuralgia
Its History And Treatment

By

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to
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whose encouragement and
constant help have made
this volume possible

PREFACE

Trigeminal neuralgia has been recognized as a disease for centuries; it presents well defined symptoms; it has such distinctive features as greater frequency among women, an observation recorded at the time of its first description, and an overwhelming predilection for the right side; yet it still baffles all attempts to fathom its causes. Methods affording relief have been found, but the circumstances producing the pain remain unsolved. The enigma it has presented has brought methods of treatment as varied and as unproved as the disease itself. The need, as Osler has said, has been great to know not only what to do, but also what to leave undone.

The aim of this volume is to present an historical background of trigeminal neuralgia, to establish its foundation in anatomy and physiology, and to advocate the use of such procedures in its treatment as experience has proved to be of value and astute clinical judgment has shown to be sound. Consideration of the facial and glossopharyngeal nerves, since they are phylogenetically and clinically interwoven with the trigeminal, has of necessity been included in this study.

Where so much depends upon the precise procedure followed, it seemed desirable to present the experiences and end results of the work of a single surgeon rather than the combined results of a number of men working in a given hospital. In the hands of one individual the procedures followed are relatively constant, whereas in the work of several men a number of unknowns must inevitably be considered in evaluating the results attained. The operations forming the basis of this study were all done by the senior author and in evaluating them the responsibility for their defects must rest on his shoulders alone. Similarly the opinions expressed are in great measure his. The chapters on non-surgical treatment, alcohol injection and the statistical studies are those of Dr. Ransohoff. No attempt has been made to cover all of

the extensive literature but it is hoped that the more important views have been presented and that controversial subjects have been critically discussed in the light of experiences, without prejudice

We are grateful to the staffs of the New York Academy of Medicine and the Library at the College of Physicians and Surgeons of the Columbia Presbyterian Medical Center for their untiring efforts and generous help and to Dr F N L Poynter Wellcome Library London who very kindly sent a complete microfilm of Andre s contribution on Tic Douloureux

Wiedersheim s Comparative Anatomy and Ariens Kappers Huber and Crosby s Comparative Anatomy of the Nervous System of Vertebrates have been freely drawn upon Further acknowledgments are due to numerous medical journals and medical publishers for permission to use illustrations and quotations which have contributed greatly to the value of the work, particularly the various publications of the American Medical Association the Annals of Surgery Surgery Gynecology and Obstetrics the Journal of Neurosurgery the Journal of Nervous and Mental Diseases and Brain

We extend our thanks to Miss Marion Crowell for her many suggestions corrections and careful reading of the manuscript and last but certainly not least the senior author would particularly like to express his gratitude to the Neurosurgical Residents of the Neurological Institute who over the years by their devotion help and interest have contributed immeasurably to the end results reported here

B S
J R

The Neurological Institute
New York City

I thought then that an attempt to select and arrange the materials that were diffused through a variety of different works, together with such information as I have been able to obtain from several very respectable practitioners of surgery and medicine, and such observations as I have had an opportunity of making from my own practice, might not be entirely useless And I shall consider myself particularly fortunate, if the contents of this pamphlet should interest any gentleman to communicate his opinions on a disease which at present seems to be so little under the influence of medicine, or to suggest any improvement or additions to the account which I now with much diffidence offer to the public

SAMUEL FOTHERGILL

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TRIGEMINAL NEURALGIA

CHAPTER I

HISTORICAL BACKGROUND OF THE TRIGEMINAL NERVE AND TRIGEMINAL NEURALGIA

The trigeminal nerve was first recognized by Fallopius in the sixteenth century. Vieussens, the French anatomist, more than a hundred years later identified the semilunar ganglion, and Hirsch of Vienna named it the gasserian ganglion after his teacher Johann Ludwig Gasser.[1] In a detailed description of the trigeminal nerve in 1748 Meckel gave us an understanding of its dural covering—Meckel's cave—as well as a description of the sphenopalatine ganglion, which also goes by his name. Centuries earlier Galen had included the ophthalmic with the nerves of the orbit (excepting the optic) as belonging to the second pair of cranial nerves, assigning the maxillary to the third and the mandibular to the fourth pair.

The variation over the years in the classification of the cranial nerves was, in large part, due to failure to recognize the trigeminal as a single nerve, while the facial, auditory, and vestibular were thus regarded, as were the glossopharyngeal, vagus, and spinal accessory. Galen (120-200), Mundinius (1276-1326) and Laurentius (1558-1607) held to seven pair of nerves; Fallopius (1526-1560), Eustachius (1524-1574) and Vidius (1569) to eight; Columbus (1516-1559) and Willis (1664) to nine. Von Sommering (1778) is responsible for the eventual duodecimal classification.

In general, interest centered in the gross anatomy, though attempts to understand the function of some of the cerebral nerves were made by Galen and Fallopius, the former conducting his studies in living animals and the latter in criminals. It was not, however, until Charles Bell's (1821) epochal contribution *On the Nerves: Giving an Account of Some Experiments on Their Structure and Function* that any real understanding was

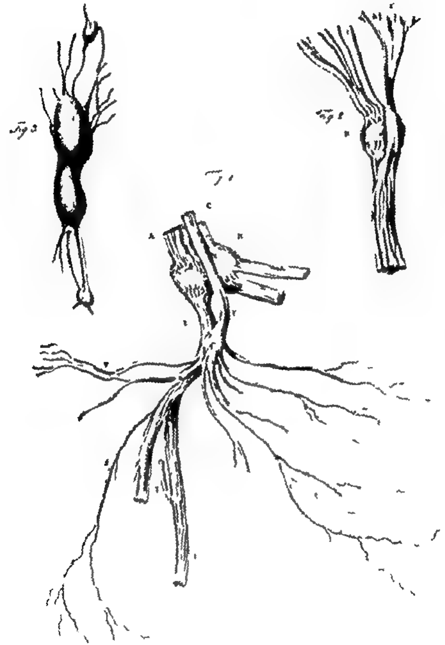

Fig 1 Dissection of the trigeminal nerve demonstrating the motor root serving the manducatory muscles Charles Bell *Philosophical Tr Roy Soc London* 1829 C and E motor root Courtesy New York Academy of Medicine

established of the motor and sensory aspects of these important structures * In a second paper Bell (1829) confirmed the concept that the trigeminal, like the spinal nerves included a motor and sensory root the motor serving the manducatory muscles while the facial muscles were served by the *portio dura,* or seventh nerve

The fifth nerve wrote Bell is usually called trigeminus from piercing the skull in three grand divisions But when it has been shown that it is composed of two distinct roots having different functions the accidental circumstance of its divisions passing through the bones yields in importance to another inquiry How is the muscular portion of the nerve distributed? This Bell showed conclusively supplied the muscles of mastication The motor division of the fifth nerve passes under the gasserian

---

*Bell paid tribute to his brother in law a Mr Shaw whose untimely death before the publication of Bell s second paper deprived him of an industrious and sympathetic collaborator Shaw had worked with Bell in his various experiments and went to Paris in 1821 to demonstrate their findings to Magendie and others at nearby Charenton At this time an idea was thrown out that the fifth nerve was no more than the sensitive nerve of the face accidentally separated from the muscular nerve (the portio dura) Perceiving that if this notion prevailed we should be thrown back into our former state of confusion and to put the matter beyond all question Mr Shaw performed those experiments which are contained in this paper

Magendie (1822) a year after Shaw s visit in a report on the motor and sensory function of the nerves makes no mention whatever of the visit and demonstration After Magendie published his paper Shaw wrote to him calling his attention to the fact that Charles Bell had done this work some thirteen years before It had been privately printed and had been a part of Bell s anatomical teachings in London for years

Magendie says that for some time he wished to lay bare the spinal nerves but that the bony vertebral column made it difficult However during the previous month a litter of eight puppies six weeks old had been brought to him and in them it was easy to expose the spinal nerves in the lumbosacral region and to demonstrate that after cutting the lumbosacral dorsal roots there was no response to pressure or to a needle However unexpectedly the puppy moved its leg Magendie then wanted to cut the ventral roots but they were difficult to reach He contemplated cutting them against the ventral dura but realizing that venous bleeding would make this undesirable he finally determined to reach the ventral roots as they emerged from the dura The ventral roots were then cut and the limb completely paralyzed Both dorsal and ventral roots were cut with complete loss of movement and sensibility Magendie concluded that the anterior and posterior roots had different functions—the posterior sensory the ventral motor

> But in certain cases the parts on the right side or those on the left solely, so far that a separate temple or ear or one eyebrow or one eye or the nose which divides the face into two equal parts, and the pain does not pass this limit but remains in the half of the head. This is called *Heterocrania*, an illness by no means mild even though it intermits and although it appears to be slight. For if at any time it sets in acutely, it occasions unseemly and dreadful symptoms: spasm and distortion of the countenance take place, the eyes are either fixed intently like horns or they are rolled inwardly to this side or to that, vertigo, deep-seated pain of the eyes as far as the meninges, irrestrainable sweat, sudden pain of the tendons as of one striking with a club.

In Caelius Aurelianus' description of *cephalaea* a few lines suggest, but with less certainty, that he too may have seen instances of trigeminal neuralgia.

Bretschneider (1847) and Krause (1896) credited Avicenna with the first account of trigeminal neuralgia, and he has been cited a number of times in the history of the disease in spite of the fact that his description is clearly that of facial palsy:

> This is a disease in which part of the face is pulled unnaturally, its normal shape is distorted, and the natural ability of both lips meeting is inhibited, also partially of both eyelids. Indeed, its cause is either paralysis or convulsion (spasm) of the muscles of the eyelids and of the face. You are already acquainted with these and their origin. In paralysis that which is pulled aside draws with it the other part and paralyzes it too, and if strong changes it by its own shape, and if weak it alone is paralyzed. And whenever the paralysis took place in the side, it is the contraction of a cord.
>
> These are the result of the already enumerated causes of paralysis. The result of the spasm is that when one part is in spasm the second part becomes numb, which is a natural consequence, and indeed the cause in itself of that which is in spasm.

Avicenna discusses at length pain as a symptom, and lists fifteen different categories, though none of these is mentioned in that part of his text presumably describing trigeminal neuralgia.

ganglion and free of it It is not seen when we look from up above as in the plates of Monro When the nerve is turned up and dissected this portion is seen to form about a fifth of the whole nerve (Fig 1)

In some of his earlier experiments Bell cut the infraorbital branch of the fifth nerve on one side and the seventh on the other Severence of the infraorbital resulted in loss of sensation without loss of movement whereas when the *portio dura* on the opposite side was cut sensibility to pain remained entire

In addition to his experiments Bell cited clinical instances of injury to the facial nerve causing paralysis of the facial muscles whereas injury to the infraorbital resulted in loss of sensation but no loss of motion in the upper half of the lip He quotes a patient who when a cup was put to his lips remarked that it was broken the missing part of the cup actually being in contact with the insensitive portion of the lip It was Bell's contributions which made it obvious that tic douloureux was an affliction of the trigeminal and not of the seventh nerve

The first description of a painful affection of the face which might be accepted as trigeminal neuralgia is found in the writings of Aretaeus in the first century A D Apparently Hippocrates and the earlier writers had not recognized this affliction Aretaeus in his chapter on *Cephalaea* mentions symptoms which suggest both migraine and less clearly trigeminal neuralgia with no recognition of any differentiation between them The passage suggestive of trigeminal neuralgia is as follows

> • There are infinite varieties of it (*Cephalaea*) in certain cases the pain is incessant and slight but not intermittent in others it returns periodically as in quotidian fevers or in those which have exacerbations every alternate day in others it continues from sunset to noon and then completely ceases or from noon to evening or still further into night this period is not much protracted And in certain cases the whole head is pained and the pain is sometimes on the right and sometimes on the left side or the forehead or the bregma and these may all occur the same day in a random manner

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Aretaeus *The Cappadocian* Edited and translated by Francis Adams London Sydenham Society 18 6

in the course of this distemper endure very great pain with a patience that seemed to feel noe thing) it forced her to such cries and shriek s as you would expect from one upon the rack to which I believe hers was an equal torment, which extended itself all over the right side of her face and mouth

When the fit came, there was, to use my Lady s own expression of it as it were a flash of fire all of a suddaine shot into all those parts and at every one of those twitches which made her shreeke out, her mouth was constantly drawn on the right side towards the right eare by repeated convulsive motions which were constantly accompanied by her cries This was all that appeared outwards in these fits according to the exactest observation I could make haveing had but too many opportunitys to doe it These violent fits terminated on a suddaine and then my Lady seemed to be perfectly well excepting only a dull pain which ordinarily remained in her teeth on that side and an uneasinesse in that side of her tongue which she phansied to be swollen on that side which yet when I looked on it as I often did had not the least alteration in it in colour bignesse or any other way though it were one of her great complaints that there was a scalding liquor in her fits shot into all that half of her tongue She had usually a presentiment of the fit by a little throbing upon her gum of the lower jaw where she had this summer a tooth drawn and a like throbing in the upper jaw just over against it In all this time of her being ill she has not found the least pain in all the other side of her face or teeth which hath soe wholy possessed the right side that it went even to the very tip of her tongue and the last tooth on that side—With all this torment that she endured when the fit was over there was not the least appearance of any alteration anywhere in her face nor inflamation or swelling in her mouth or cheeke very little defluction of rhewm more than what the contraction of those parts in those fits might cause Speaking was apt to put her into these fits sometimes opening her mouth to take any thing or touching her gums especially in the places where she used to find those throbings pressing that side of her face by lying on it were also apt to put her into fits These fits lasted sometimes longer sometimes shorter were more or less violent

Boring	Heavy	Relaxing
Compressive	Incisive	Stabbing
Corrosive	Irritant	Tearing
Dull	Itching	Tension
Fatigue	Pricking	Throbbing

Harris (1926) called attention to the fantastically carved capitals in Wells Cathedral in Somerset near the tomb of Bishop Button (died in 1274) to whose shrine pilgrims were said to come seeking relief of toothache and neuralgia One figure is that of a man pointing to a painful tooth while another shows the contorted face of a monk in great agony Why they sought relief here is not recorded but Harris who considered poor teeth a cause of trigeminal neuralgia informs us that when the Bishop s tomb was opened in 1818 his teeth were found to be in perfect condition

It is probable that trigeminal neuralgia had afflicted mankind for a long time before it was finally recognized as a definite clinical entity The first full description by a *physician* of this painful affection together with an account of its treatment is that by John Locke philosopher physician friend of Sydenham and author of the constitution of the State of Carolina While in Paris in 1677 Locke was called to see the wife of the English Ambassador the Countess of Northumberland who was suffering excruciating pain in the face and lower jaw In a letter to his friend Dr Mapletoft Locke gave a minute account of her suffering outlined the treatment which he had prescribed and asked for recommendations and advice

Letter IX

Sir *Paris 4 Dec 1677*

I never had a more unwelcome occasion of writing to you than now believing I can scarce send you more unacceptable news than that of the illnesse of a person whom not only you and I but all the world have soe just reason to esteeme and admire On Thursday night last I was sent for to my Lady Ambassadrice whom I found in a fit of such violent and exquisite torment that though she be as you know a person of extraordinary temper and I have seen her even

in the course of this distemper endure very great pain with a patience that seemed to feel noe thing) it forced her to such cries and shrieks as you would expect from one upon the rack, to which I believe hers was an equal torment which extended itself all over the right side of her face and mouth

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you shall think fit to consult with but I wish much more for your company than your opinion without it I am sir

Your most humble servant
John Locke

Letter X

Paris, 4 Dec 77
At One in the Afternoon

*You will certainly thinke me in great distraction when after a letter and note that I sent you already this morning I now send you this third But it is to tell you that my Lady upon a little increase of her paine apprehending the violent returne of her fits hath since the writing of my last note had a blistering plaster put on to her neck * In a little fit she had since the violence of the pain not being soe great as it usually is she had the liberty to shew me her tongue which she had some reason to imagine swollen all the left side of it being drawn up during the fit and soe seemd thicker as if it were swollen but as soon as ever the fit is over it returns to its natural state and there is noe discern able difference between the sides of it nor the least impedi ment in my Lady s speech or alteration in her voice She has especially when the fits are most violent a drinesse in her lips more than ordinary †*

It may not perhaps be amisse to let you know also that during all the pain and disorder my Lady has suffered her temper has been as good and her pulse as equall sedate and regular as that of any one in the best health only some times the violence of her pains puts her into a little sweat but as soon as that leaves her she returns presently to her ordinary good temper I am willing you should know as much as I doe of all the circumstances of her case And I should be glad you knew better what would perfectly cure it tho I wish heartily it may be over before your answer come I am Sir

Your most humble Servant
J L

* *Inter scapulas*

† *And my Lady Harvey tells me that several days before the comeing of these fits finding this unusual drieness of her lips she apprehended she should have them she having particularly observed this symptome to accompany those fits she had in the sommer*

without any regularity and the intervals between them at the longest not halfe an hower commonly much shorter

It being night when I was cald I saw noe roome for any thing else to be done but to endeavour to give her present ease by topical anodyn applications to those parts of her gums where the first beginnings of her fits appeare which had soe good an effect that that night she had two or three howers rest together without any fits besides some other little intervalls of sleepe But the next day the fits returning tho not altogeather soe frequent and violent as they had been yet bad enough to make us feare they might I thought it necessary to purge her Honour for besides that I saw noe indication for bleeding My Lady had beene soe often and soe much bleeded on the like occasion this sommer without any reliefe that there was little to be hoped from it and I thought it ought to be very waryly made use after soe much taken already The purge wrought seven or eight times the fits continuing still by intervalls after her purge soe at night as you know is usuall she tooke a quieting cordial The first part of the night she had her fits very severely but the latter part hath been more favourable and till about nine or ten of the clock that I write this there remains only an ordinary tooth ache the violence of those fits being ceased but whether we are not to apprehend their returne in this extraordinary case I cannot be over confident two or three days of ordinary tooth acke having preceded them

I wish with all my heart you were here both to assist my Lady by your better skill and to ease me of a part of that sollicitude I am under haveing the care of a person of her consideration wholy upon me she haveing had soe little successe with the French physitians here this sommer in the like case wherein for eight days together their applications did her noe good that she is resolved to trie them noe more If I durst interpose my opinion in a case soe extraordinary as this I should aske whether you did not thinke this to proceed from some affections in the nerves in the place where the tooth was drawn which draws all the rest into consent and convulsive motions on this side and that perhaps some sharpness in her blood may contribute to it I beg your opinion and of whoever else of the ablest of our physitians

Johannes Michael Fehr and Elias Schmidt published in 1688 six years after his death and referred to by both Samuel Fothergill (1804) and Bretschneider He had sharp shooting pain in his right maxilla coming on suddenly like a bolt of lightning varying in intensity rendering him unable to speak or take solid food In the fall of 1665 the pain disappeared only to return and on December 15 of that year he suffered a stroke involving the left side of his body and died on the same day

The nature of Bausch s disease was not known to him or to Fehr or Schmidt and death was attributed to the painful facial affection from which he had suffered so long Samuel Fothergill referring to this account disdainfully says By one of those very useful members of the community, who are ever anxious to ascertain the year the day the hour of every discovery it [trigeminal neuralgia] has been traced back to the year 1665 And great no doubt did the man think himself who had the felicity to discover after long toil and wearisome labour that Lawrence Bausch physician at Schweinfurth in Franconia president and founder of the Societas Naturae Curisorum died of the disorder in the year of our Lord one thousand six hundred and sixty five according to the annals of the foresaid society I have not seen the account and should much doubt the fact as I know of no instance of the disease having terminated fatally

The recognition of trigeminal neuralgia as a definite clinical entity is to be credited to Nicolaus Andre in 1756, Numerous references to his report and brief vivid description of the disease are to be found in the literature * Andre leaned strongly upon the ancients as is indicated by his advocacy of caustics which he defended on the principle that to cure extreme illness requires extreme remedies He says There is good reason not to banish completely the use of caustics in surgery since it is impossible to bring about a number of cures without their aid

It is most interesting to compare Andre s and Fothergill s approach to an apparently new disease Andre reverts immediately to the ancients According to the authorities who are the most

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André s original description was not available in the New York Academy of Medicine or in any other of our American libraries

Later an old French almanac was found belonging to Locke containing within its pages notes concerning the treatments he had prescribed and his reflections Because of the wintry weather he feared having his patient go to stool and consequently hesitated to give her an opening medicine though aware of the advantage which would accrue Finally he overcame his reluctance and in spite of the cold and the inconvenience he thoroughly purged the lady and in several weeks she was well

Shortly thereafter Locke heard from Sydenham Upon reading the letter Locke says I was ready to cry out The spirit of the Prophets is upon the sons of the Prophets I having in what I have done here not only proceeded by the same method but used the very same remedy he directed as to the maine

Both Sydenham and Locke studied medicine at Oxford While Locke did not stand for his examinations he nevertheless practiced in Oxford made rounds with Sydenham attended Sydenham s family and shared with that physician the medical care of Lord Ashley later the Earl of Shaftsbury Locke s objective approach and philosophical views helped to mold English medicine He urged medical men not to build castles in the air of their own but to survey well those that are on the ground Nicely to observe the history of diseases in all their changes and circumstances is a work of time accurateness attention and judgement He belittled the importance of anatomy then so dominant We see not its tools and the contrivances by which nature works Both he and Sydenham sought to discover for themselves what is true in the light of reasonable evidence I can no more do anything by another man s understanding than I can see by another man s eyes The influence of Locke and Sydenham helped build a school of English physicians noted for their accurate detailed and careful observations so well exemplified in another English physician to whom we shall later refer John Fothergill

Locke s account of his patient was preceded by that of Johannes Laurentius Bausch the distinguished founder of the Imperial Leopoldian Academy who suffered with the disease for four years before his death in 1665 A vivid description of Bausch s symptoms is found in his eulogy by the secretaries of the Academy

REMARQUES

Sur certains mouvemens convulſifs.

AVANT de paſſer aux faits énoncés, il ne ſera pas hors de propos de donner une juſte idée de la maladie qui m'a déterminé à faire les différentes opérations qui feront le ſujet de ces Obſervations. Maladie cruelle & obſcure, qui cauſe dans certaines parties du corps, principalement à la face des agitations violentes, fait faire à cette partie des grimaces hideuſes qui mettent un obſtacle invincible à la réception des alimens, qui éloignent le ſommeil, interceptent & lient ſouvent l'uſage de la parole agitations qui, quoique vagues & périodiques en elles-mêmes, ſont néanmoins ſi frequentes,

←
Fig 2 Title page of the volume published by Andre describing trigeminal neuralgia as tic douloureux 1756 Courtesy Dr F N L Poynter Wellcome Library London

OBSERVATIONS PRATIQUES SUR LES MALADIES DE L'URETHRE,

ET SUR PLUSIEURS FAITS

convulsifs, & la guérison de plusieurs Maladies Chirurgicales, avec la décomposition d'un Remede propre à reprimer la dissolution gangreneuse & cancereuse, & à la réparer, avec des Principes qui pourront servir à employer les differens Caustiques.

Par M. ANDRÉ, Maître ès Arts & en Chirurgie, Chirurgien de la Charité de la Paroisse Royale de Saint Louis de Versailles, & ancien de la Royale Maison de Saint Cyr.

A PARIS,
Chez DELAGUETTE, Imprimeur du Collége & de l'Acad. Roy. de Chir. rue S. Jacq. à l'Olivier.

M. DCC. LVI.

Avec Approbation & Privilége du Roy.

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qu'elles se font sentir plusieurs fois un jour, dans une heure, quelqu[...] sont sans relâche, & se renouvelle[...] chaque minutte. Enfin lorsque c[...] qui sont attaqués de cette maladie v[...] lent articuler quelques mots, ou [...] muer la partie affectée, aussi-tôt le n[...] morbifié entre en contraction, & le[...] ôte la libre faculté d'agir.

Mais quel nom donner à cette m[...] ladie, qui toute étrange qu'elle paroi[...] se, n'est cependant pas à beaucou[...] près aussi rare qu'on se l'imagine, puis[...] qu'en assez peu de tems, j'ai vû huit à dix personnes qui en étoient atteintes? Quel nom, dis je, donner à cette maladie, comment la caractériser d'une maniere distinctive & exclusive à toute autre? C'est ce qui ne sera pas facile: car ce n'est ni convulsion proprement dite, puisqu'on entend par convulsion proprement dite un retirement involontaire & perpétuel des nerfs & des muscles vers leur origine.

Le mal en question n'étant pas perpétuel, ne peut conséquemment être mis au rang des convulsions proprement dites.

Par la même raison ce n'est point le

Fig 3 Andre's description of trigeminal neuralgia

precise the most reasonable, and after all the books I have consulted I confess it is extremely difficult to classify the singular distinctive characteristics of the disease He conceives of the illness in terms of convulsions using the reasoning of Aretaeus and Caelius Aurelianus in establishing a differential diagnosis between true tonic convulsions tetanus and *spasm cinique* He quotes Caelius Aurelianus as saying that *spasm cinique* forces one to retract the lips as in smiling and sometimes involves the eyelids the nares the mouth and shoulders the weight of which forces them to hold themselves rigid in order to maintain their equilibrium This picture he states more nearly approaches that which he himself had observed hastening to conclude that the convulsive movements which disturbed the patients under his care could not be described under the name *spasm cinique* but were more appropriately designated *tic douloureux* Both terms imply contortions and grimaces accompanied by violent almost unbearable pain

By contrast Fothergill without resort to the thinking of his predecessors saw for himself what is true in light of reasonable evidence that the disease is not essentially a convulsive disorder but a painful affection of the face What therefore I have to offer upon the nature of this disease is rather submitted to your consideration as matter of further inquiry than as opinion sufficiently established

Andre reported five cases the first of which he saw in 1732 Up to the publication of his report in 1756 he had seen eight or ten patients with this affliction Of the five cases reported in detail neither the first the fourth nor the fifth were true trigeminal neuralgia The report of the first case is given in detail as follows

> Madame was the first to undergo the operation concerning which I shall render an account to the public Before reporting the treatment which I gave her it is necessary to describe her original condition and the measures which had been employed to save her from the deplorable state to which she had been reduced for ten years
>
> This lady came from Paris to Versaille in 1722 She re ceived a blow from the edge of a table which hit her fairly

qu'elles se font sentir plusieurs fois dans un jour, dans une heure, quelquefois sont sans relâche, & se renouvellent à chaque minutte Enfin lorsque ceux qui sont attaqués de cette maladie veulent articuler quelques mots, ou remuer la partie affectée, aussi-tôt le nerf morbifié entre en contraction, & leur ôte la libre faculté d'agir.

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Par la même raison ce n'est point le

Fig. 3 André's description of trigeminal neuralgia

interior part of the face—but on one side only—as if the scalp were being torn from her forehead and temple

Such was the sad condition in which the patient found herself for a number of years She spared neither consultations nor remedies to find relief She tried different measures from time to time—antivenereal antiepileptic antispasmodic anti scorbutic she took the baths and limited her self to milk as nourishment, the solvents and anodynes had their turns painful poultices were applied for a time and on several occasions vesicants were used Finally she succumbed to consulting charlatans a number of empirics saw her with their vaunted elixirs In a word all attempts failed undoubtedly because all of the remedies were too far away from the source of the disease The situation remained unchanged

It was at this juncture that a more radical approach to the disease was suggested

A skillful man a man worthy of all the reputation he enjoyed a man who so well merited the praise which a delicate and laconic pen had accorded him in distinguished societies the late M Marechal personal physician to the King [Louis XIV] now proposed to attack the disease in question at its source which he appeared to know and by an operation familiar in formal surgery

Andre cannot refrain at this point from injecting a mention of caustics anticipating his own successful treatment of the case Crediting Marechal with having outlined for him a difficult and formidable task which that eminent surgeon could him self have accomplished more slowly and surely by the use of caustics Andre adds One will readily understand that so slow a cure would not be possible for the most distinguished man of his century He could not devote the time and the care required over a period of ten to twelve days in the necessary use and appli cation of different caustics

Returning to his account of the case Andre continues

The illustrious head of surgery having outlined the advan tages of the operation which he planned to perform overcome by the history which the patient recited touched by her tears and struck by the terrible grimaces caused by the continued tics was led in his charity to overcome all obstacles and seize

severely over the inferior part of the orbit and the side of the nose precisely over the external surface of the maxillary bone At the time of this blow she felt a steady and lancinating pain but being naturally courageous she applied brandy over the contusion and patiently awaited the effect of this topical application It was not as helpful however as she had hoped for the contusion soon degenerated into an inflammation and this inflammation terminated in an abscess which was treated superficially Because of the duration of the process the pus acquired a certain amount of gas and consequently a foul odor and acid corrosive character The fluid appeared most prominently between the incisors a little at a time being discharged at first followed by a large amount considering the size of the tumor which was about as large as a filbert When pressure was exerted above the tumor fluid was immediately discharged in an appreciable stream Finally it became so abundant that if the mouth were opened wider than usual the cyst would empty itself

The patient put up with the inconvenience of this fistula an entire year If only she had been able to persist! But believing herself to have found means of alleviation she applied without reserve all the suggested medicines and useless remedies proposed by well meaning friends Consequently she had a tooth pulled a few months later a second tooth and then a third they were the last three molars or more accurately the first molar the canine and the incisor This last operation closed the fistula and stopped the discharge and had it not been for an alteration in the bone or defect in the blood of this lady it is probable that the procedure would have brought about a cure But fatal error! What was considered the end of a slight supportable illness developed into a most acute malady I refer to the onset of tic douloureux which afflicted her day and night deprived her of sleep and hindered her in performance of the functions necessary to sustain life In fact these disturbances periodic as they were became so frequent that she rarely had five or six minutes of peace in an hour She could not drink eat cough expectorate blow her nose without producing pain she was reduced to a diet of soup and puddings she had to drink with a spoon and was obliged to rest a considerable time after each swallow If she touched her upper lip with her finger she suffered the most cruel stinging in the

inferior part of the face—but on one side only—as if the scalp were being torn from her forehead and temple

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upon a proper moment for his operation He had the patient sit in a chair the head well supported He held the upper lip and using a scalpel cut between the gum and the maxillary bone and uncovered as well as he could the maxillary bone to the edge of the orbit His intention judging by the appearances was to cut the infraorbital nerve at its emergence having determined upon this plan due to the location of the principal point of the pain below the orbit This skillful artist—could he execute his proposed project? It is certainly beyond belief—the field was too obscured to permit him to cut with certainty

The hemorrhage which followed the operation was of little consequence and the loss slight easily controlled by pressure The patient slept five or six hours during the day of the operation and appeared considerably relieved But in a short space of two or three days all hope was dissipated from then on the spasmodic pain again returned and the attacks became so violent the dressing could not be kept in place The wound healed but the pain returned

In this manner the patient had passed the two years from 1730 to 1732 at which time I had occasion to see her and to learn all the circumstances which had accompanied her various treatments

The lady had given up hope of a cure and had engaged me to see her often Consequently I was frequently a witness to her suffering Each time I had occasion to see this sad situation I felt within me a sense of confusion that our surgical art so fertile in resources should be impotent in this case

All these failures made me redouble my efforts and stimulated me to reflect deeply and to study carefully the plan I had considered and to pass upon it critically After a few bad moments light began to enter my mind little by little concerning the delicate methods which I wished to employ

I hoped to leave nothing to hazard in a land so enlightened and under circumstances where I must be most cautious since I must to some extent disclose my plan to the public and then hide behind the curtain to listen and weigh quietly its criticisms

Some will say that in following my plan nervous people will be completely shocked and caused terrible and widespread disturbances others may say that I have formed a dam with considerable backflow to the brain Again others will suggest

that the enterprise is a rash one that a cure is impossible and wildly fanciful that the wound which results will remain fistulous and never heal completely or that the healing will be only palliative Finally ignorance and jealousy masquerading under various pretenses unfortunate in the extreme will overtake me

So with great misgiving André followed the plan of Maréchal to attack the infraorbital nerve at its exit, not however, by surgery but by applying caustics over a period of days until the nerve was laid bare and destroyed

The success of the procedure is attested by the following testimonial received by André from his patient

> I the undersigned certify to whom it may concern that I have been perfectly cured of a disease similar to that of the late M Lespart by an operation which M André surgeon in this city performed two years ago having done it upon me for the first time and not having any other remedies of help to me before this after long suffering for ten full years and after having consulted numerous physicians and surgeons from whom thanks to God I have been delivered In testimony of this I have given the present certificate similar to the one we have already given to the Mercury M Lespart and I so that all the world may know of our cure At Versaille 18 Jan 1731 Signed Madame Mignon

In a similar manner André treated his second patient—the M Lespart mentioned in Madame Mignon's testimonial The success of the procedure in this instance was recognized by a testimonial from the surgeon to the king

> I the undersigned surgeon to the king and Surgeon Juré in Paris having seen M Lespart formerly at Satory near Versaille with an attack of convulsive disease involving the lower jaw and knowing of all the remedies which he had previously tried without any relief certify that having had recourse to M André master surgeon at Versaille he was perfectly cured by an operation which M André performed and by this maneuver destroyed the cause of the malady and rendered him capable of doing his work I have been a witness to several of his dressings and have seen the patient more than six months after his cure and accordingly I have made the present certificate Signed Versaille 18th February 1734 Boisaillaud

It is obvious that the first patient had an inflammatory process which was followed by an exquisitely painful neuritis and not true trigeminal neuralgia as we understand it today Nevertheless Andre s account of her suffering is an accurate description of trigeminal neuralgia as precise as any available

Andre s second and third cases were apparently authentic trigeminal neuralgias successfully treated in the same manner The fourth case involved pain in the head neck and shoulder without definite localization but was nevertheless designated by Andre as tic douloureux

Fig 4 John Fothergill 1712 1780 Courtesy New York Academy of Medicine

The fifth patient had small pustules filled with yellowish red serum over the forehead maxillary region nose and lips which as long as they discharged caused no pain but as soon as they ceased to discharge became painful The infraorbital nerve was uncovered but the patient was unwilling that the wound be left open and in five months the pain returned Andre then removed the scar suppuration was resumed and the patient lived three years in comfort

André considered tic douloureux to be due to vicious nervous liquids which irritated the affected nerve and caused the painful shocks

Some seventeen years after the French physician's account of tic douloureux John Fothergill (1773) unaware of this report

Medical Obſervations and Inquiries 129

XIV *Of a painful Affection of the Face, by* J Fothergill, *M D F R S*

To the MEDICAL SOCIETY *in London*

GENTLEMEN,

WHEN I related to you, at one of our late aſſemblies, the purport of the following narrative, ſeveral inſtances of a ſimilar affection were then recollected, caſes, which though nearly akin in appearance to the toothach, and that kind of diſorder of the jaw which is ſometimes called the rheumatiſm, ſometimes the ague in the head, and which had not given way to thoſe remedies and applications which in ſuch complaints are moſt commonly ſucceſsful in curing them, you then thought that a more particular account of this diſeaſe, and the method of removing it, might not be unacceptable to the public, for though it does not every day occur, yet to be able to diſtinguiſh and to cure, with ſome degree of certainty, a diſeaſe, that during the time it

VOL V K laſts

Fig 3 Title page of John Fothergill's contribution *Of a painful affection of the face* 1773 Courtesy New York Academy of Medicine

presented fourteen cases of painful affections of the face with such clarity accuracy and minuteness that his description today is as valid an account as the day it was written Fothergill s description is as follows

> It is a disease that has occurred to me several times it seems to be of a singular nature and so far as I know al together undescribed
>
> This affection seems to be peculiar to persons advancing in years and to women more than to men I never met with it in anyone much under forty but after this period no age is exempt from it
>
> The case does not occur very frequently I can recollect about fourteen instances in the course of my business This last year I was consulted by two women one nearly eighty and the other about fifty years old both of them in other respects healthy
>
> From imperceptible beginnings a pain attacks some part or other of the face or the side of the head sometimes about the orbit of the eye or the side of the head sometimes about the temporal bones are the parts complained of The pain comes suddenly and is excruciating it lasts but a short time perhaps a quarter or half a minute and then goes off it returns at irregular intervals sometimes in half an hour sometimes there are two or three repetitions in a few minutes
>
> The kind of pain is described differently by different persons as may be reasonably expected but one sees enough to excite one s compassion if present during the paroxysm
>
> It returns full as often in the day as in the night Eating will bring it on some persons Talking or the least motion of the muscles of the face affects others the gentlest touch of a hand or a handkerchief will sometimes bring on the pain whilst a strong pressure on the part has no effect
>
> It differs from the toothache essentially in many respects It affects some who from age have few or no teeth remaining It most commonly seizes some part above the sockets of the teeth yet the teeth are sometimes affected with an exquisite sensibility upon endeavoring to chew even the softest sub stance The lower jaw is seldom attacked with this disease

Fothergill did not indicate whether the facial or the trigem inal nerve was involved In two of his fourteen patients the

presence of a hard tumor of the breast led him to suspect that the cause of these extreme pains in the face might be of some cancerous nature the method of cure in other circumstances seemed to corroborate the suspicion In a footnote he comments that he had met with two more cases (making sixteen in all) of this painful affection, in four of which hard tumors were present on the breast His patients were given increasing doses of extract of hemlock which he felt cured or at least alleviated their pain

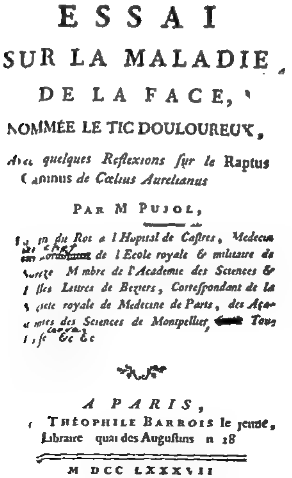
In one of Fothergill s earlier reports he refers to a case with similar pain apparently not included in this report which he had successfully treated with the bark of hemlock It was interesting to find that the first patient with this affliction to come under Fothergill s observation had been referred to him from the American colony

> A middle aged man healthy active and temperate was attacked with pain in one cheekbone above the antrum Highmorianum for which he could assign no cause It grew to be severe and continual but was sometimes heightened to a degree almost beyond bearing Though a native of England his residence was in one of the American Colonies * He applied to many very able practitioners there but without obtaining more than temporary mitigation—the bark warmth cold sea bathing and drains of every kind were made use of but to no purpose Several teeth were drawn and an opening made in the antrum but fruitlessly The pain sometimes abated but it never wholly went off its returns were frequent several times in an hour and excruciating so as to produce spasmodic contractions of every muscle about the face and neck and even affecting the whole body

Fothergill prescribed 20 grains of extract of hemlock with instructions to increase it In a week the patient was better he continued to improve and returned to America almost free of pain

* It will be remembered that Fothergill a Quaker friend of the American colony and of Benjamin Franklin was helpful in founding the Pennsylvania Hospital He sent eighteen half size crayon *drawings of the human body* framed and glazed three cases of anatomical castings and one case containing a skeleton of an adult and of a fetus so that this material might be available to enable Dr Shippen to begin a course of anatomy in Philadelphia In many other ways he furthered the interests of both the hospital and the medical school

Following Andre's and Fothergill's portrayals of this painful affection of the face, occasional cases were reported, although tic douloureux was still not well known. Thouret (1782) considered it to be an affection of the nerves of the face, especially in the region of the distribution of the infraorbital, but also implicating the lower jaw. The plexus of nerves involved he called "goosefoot plexus." While he accepted neither Fothergill's "cancerous acrimony" nor Pujol's "humors," he advanced no theories of his own. Chaussier (1802) classified the various forms of tic douloureux according to the anatomical distribution of the three trigeminal divisions but included the seventh nerve as well as the



ESSAI
SUR LA MALADIE DE LA FACE,
NOMMÉE LE TIC DOULOUREUX,

Avec quelques Réflexions sur le Raptus Caninus *de Cœlius Aurelianus.*

PAR M. PUJOL,

Médecin du Roi à l'Hôpital de Castres, Médecin chef *de l'École royale & militaire de Sorèze, Membre de l'Académie des Sciences & Belles Lettres de Béziers, Correspondant de la Société royale de Médecine de Paris, des Académies des Sciences de Montpellier, Toulouse, &c. &c.*

A PARIS,

Chez THÉOPHILE BARROIS le jeune, Libraire, quai des Augustins, n. 18.

M DCC LXXXVII.

Fig. 6. Title page of Pujol's essay, Tic Douloureux, 1787. Courtesy New York Academy of Medicine.

seat of the disease In its treatment he employed acupuncture without much success

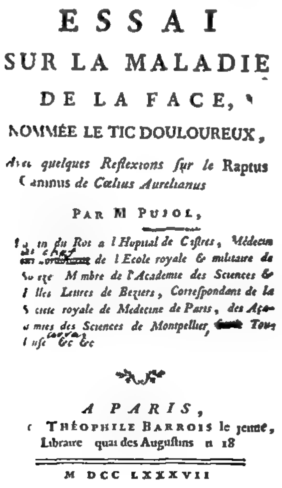
Two most important communications were those of Pujol (1787) and John Fothergill s nephew, Samuel Fothergill (1804) Pujol says of the disease " it is even so little known in our time that there are but a few modern physicians who have spoken of it One should not then be surprised that it has stubbornly resisted to the present time the various measures which have been conceived to combat it As may be seen from Pujol s title page he like Andre still harked back to the thinking of the ancients considering tic douloureux as in part at least an unusual form of a convulsive state the *raptus canius* of Caelius Aurelianus Among the English commentators its dominant painful aspect was stressed as it had been originally by John Fothergill

Pujol s portrayal of the disease was comprehensive and his description of the symptoms equal to Andre s

When we observe a patient who actually feels a pretty sharp attack of tic douloureux in the cheek we see him knit his brows both eyelids are strongly compressed and the commissure of the lips is drawn towards the ear as in sardonic laughter The lower jaw remains immobile and held in the same situation in which it was at the time of the attack respiration is slow as if suspended and often the patient dares not make the least cry or utter a single exclamation He even seems to dread the slightest motion of the body his forced attitude and almost ecstatic state much better express the violence of his pain than any verbal description No sooner is he free from the attack than he complains of what he had felt in the most mournful tones and in the most energetic language

The patient soon becomes indifferent to the charms of society and incapable of attending to any other object than himself The pains are more frequent during the day than in the night probably from there being at this latter time fewer causes of irritation and they are more frequent during conversation than in silence and still more so during mastication when the attacks often succeed each other with such rapidity as to appear like one continued paroxysm with scarcely an interval of cessation In general one side is affected with this dreadful disease but as there are cases recorded in which both

Following Andre's and Fothergill's portrayals of this painful affection of the face, occasional cases were reported, although tic douloureux was still not well known. Thouret (1782) considered it to be an affection of the nerves of the face, especially in the region of the distribution of the infraorbital, but also implicating the lower jaw. The plexus of nerves involved he called "goosefoot plexus." While he accepted neither Fothergill's "cancerous acrimony" nor Pujol's "humors," he advanced no theories of his own. Chaussier (1802) classified the various forms of tic douloureux according to the anatomical distribution of the three trigeminal divisions but included the seventh nerve as well as the



ESSAI
SUR LA MALADIE
DE LA FACE,
NOMMÉE LE TIC DOULOUREUX,

Avec quelques Reflexions sur le Raptus Caninus *de Cœlius Aurelianus.*

PAR M. PUJOL,

Médecin du Roi à l'Hôpital de Castres, Médecin en chef de l'Ecole royale & militaire de Sorèze, Membre de l'Académie des Sciences & Belles-Lettres de Béziers, Correspondant de la Société royale de Médecine de Paris, des Académies des Sciences de Montpellier, Toulouse, &c. &c.

A PARIS,
Chez THÉOPHILE BARROIS le jeune, Libraire, quai des Augustins, n. 18.

M DCC LXXXVII.

Fig. 6. Title page of Pujol's essay, Tic Douloureux, 1787. Courtesy New York Academy of Medicine.

CONCISE AND SYSTEMATIC ACCOUNT

OF A

PAINFUL AFFECTION

OF THE

NERVES OF THE FACE;

COMMONLY CALLED

TIC DOULOUREUX.

BY

S FOTHERGILL, M D

PHYSICIAN TO THE WESTERN DISPENSARY

London:

PRINTED FOR J MURRAY, 32, FLEET STREET

1804

Fig 7 Title page of Samuel Fothergill's (nephew of John Fothergill) description Of a painful affection of the nerves of the face 1804 Courtesy New York Academy of Medicine

sides suffered at the same time we cannot lay it down as characteristic of the disease The disease appears with lightning like suddenness most frequently attacking the side of the nose immediately below the maxilla in the region where the superior maxillary nerve makes its exit from the infraorbital foramen Yet sometimes it appears in other parts such as the temple the lower jaw the eyeball the forehead or some parts of the scalp

It would thus appear that Pujol saw all three divisions involved including the ophthalmic After tic is established and has had time to develop itself, it requires but a *coup d oeil* to recognize and to distinguish it from all other diseases It is surprising how often tic douloureux is confused with toothache Unfortunate and useless extraction of an entire row of teeth has usually followed that diagnostic blunder This regrettable error is not infrequently made even today despite all the advances of our knowledge

In his differential diagnosis Pujol considered hysteria odon talgie rheumatism of the face and mucous engorgement of the maxillary sinus Etiologically he implicated three humors as likely causes—gout scurvy and catarrh He believed that in spite of occasional success following infraorbital section more than one nerve would need to be cut since the painful area is so richly supplied He did not attribute the disease solely to the trigeminal nerve

John Fothergill had not given a name to the painful affection of the face which he had described with such accuracy whereas Andre had begun his account by applying a name though his designation is inaccurate in its connotations stressing as it does a convulsive aspect of the affliction which was evidently dominant in André s view

Samuel Fothergill in the preface to his *Concise and Systematic Account of a Painful Affection of the Nerves of the Face Commonly Called Tic Douloureux* discarded the term tic since it is sometimes used to express trismus and appeared to him therefore to be inappropriate Nor did he approve of *hemicrania idiopathica*, which is a distinct disease He objected also to an eponymic designation (the Germans had called the disease after

tic douloureux.[?] Actually Marechal surgeon to Louis XIV, was the first to attempt section of the peripheral branches of the trigeminal nerve for this purpose. The first two patients treated by Andre to whom reference has already been made had been operated upon unsuccessfully by Marechal one in 1730 and the other in 1732. While conflicting statements have been made concerning these operations; Andre's original text includes a fairly accurate description of the procedure followed. In these two cases at least no attempt was made to cut the portio dura. The first operation was designed to section the infraorbital nerve at its exit from the infraorbital foramen but because of hemorrhage the surgeon was unable to bring the nerve into view and this in spite of the fact that before trying the procedure on the living he had performed it a number of times on cadavers. Galen had observed that if a nerve were cut, convulsions of a muscle immediately ceased and paralysis ensued. It was with this in mind that Marechal sought to cut the nerve believing that if he were successful the so called *tic convulsive* would disappear.

In the second case Marechal made an incision in the mouth from the angle of the jaw as far as the incisor laying bare the bone as much as possible. The operation finished he applied the usual dressing. The condition of the patient was not improved hemorrhage up to this time was of little consequence but on the seventeenth day a sudden hemorrhage took place so extensive that it endangered the patient's life and was stopped with difficulty.

The temporary palliation which followed the operation Andre attributed to depletion brought about by severe loss of blood which lessened the elasticity of the vessels rendering them less susceptible to convulsions. The relief lasted only two months during which time the patient had a few slight attacks and the pain then returned in its original severity. In May 1732 Andre laid the bone bare and destroyed as much of the nerve as possible applied a hot iron to hasten exfoliation of the bone and enlarged the mental foramen with a perforating trephine. After removal of the cauterized bone the canal and nerve were exposed and the nerve destroyed with liquid caustic.

his uncle *Dolor Faciei Fothergilli)*, saying "We may call an island a star or a flower by the name of the discoverer yet to introduce such a practice in the nomenclature of diseases would only breed confusion" His suggestion was *faciei morbus nervorum crucians*, which he considered as descriptive and more accurate

In speculating upon the cause of the disease which had engaged his attention the elder Fothergill had thrown out the conjecture that it might be the result of a "cancerous acrimony" and there were those who accepted this suggestion as his considered opinion To these Samuel Fothergill took exception He himself wrote "I do not even hazard a conjecture but will wait till greater experience and information shall throw some light on a subject which opinion cannot explain nor hypothesis prove"

Samuel Fothergill drew extensively upon the work of Pujol and his uncle but added little to what was already known Nevertheless it was to him that Benjamin Hutchinson a few years later (1820) dedicated his monograph on *Cases of Tic Douloureux Successfully Treated with Ferous Carbonate*, saying "You have successfully investigated the history the predisposing proximal and remote causes of *tic douloureux* or *morbus nervorum crucians* together with the usual modes of treatment As a fellow laborer therefore in the same field of inquiry allow me to address to you these few sheets" Hutchinson found tic douloureux usually confined to the superior maxillary nerve and to the portio dura of the seventh The year before Bell's contribution he made the interesting and significant statement "when the portio dura is involved the pain is in the ear *mastoid and angle of the jaw*" an excellent observation the earliest we have encountered of what probably was glossopharyngeal neuralgia

About the same period a number of dissertations appeared among which should be mentioned those of Barbarin (1817) and Reverdit (1817) Reverdit introduced the term prosopalgia combining the Greek word *prosopon* face and *algia* pain a designation later adopted by Hunt in describing a deep form of geniculate neuralgia

Bretschneider and Krause erroneously credited Schlichting (1748) as having done the first peripheral nerve operation for

CHAPTER II

EMBRYOLOGICAL AND COMPARATIVE ANATOMICAL CONSIDERATION OF THE TRIGEMINAL AND FACIAL NERVES

In view of the conflicting opinions concerning the function of the trigeminal and facial nerves a brief consideration of the embryologic and comparative anatomy appears desirable.

Adelmann's (1925) extensive embryologic study of the neural folds and cranial ganglia in more than two hundred rat embryos permitted him to follow the developing trigeminal ganglionic mass from its first appearance in the five somite embryo. The trigeminal crest appears along the territory of the prospective midbrain from the region of the second myotome; the ophthalmic nerve emerges anterior to the myotome while the maxillo mandibular arises behind it. The former corresponds to nervus II of the amphioxus and is considered the homologue of the trigeminal deep ophthalmic. The entire trigeminal ganglion, the largest of the embryo, is developed from the ganglionic crest but Adelmann was not sure whether the neural crest cells arose from the edges of the neural folds or from the roof of the neural tube. He could not confirm the opinion of Giglio-Tos (1902), whose report was based on a single human embryo of fifteen somites, that the semilunar ganglion is made up of neural proganglia, epibranchial proganglia and branchial pronerves. From a study of Giglio Tos's illustrations Adelmann believed that mesenchymal condensations had been confused with ganglionic anlagen. He found no evidence of inclusions of epibranchial placodes or of increased activity of the overlying ectoderm or of any cells being pinched off to join the semilunar ganglion mass. He considered the placodes to represent rudimentary sense organs developing under stimulus of nervous control and regressing when the stimulus, due to growth shifting

A number of operations were subsequently performed on the peripheral branches of both the trigeminal and facial nerves for the relief of the intolerable pain of tic douloureux

> Louis (1766) at the suggestion of Mr Tronchin chief physician to the Duke of Orleans and professor of the University of Geneva had just affected in Paris the most unusual cure one could imagine a cure which is possibly unique or at least so rare that there is not a similar case in France The Prior Premonstrants who had suffered unbearable pain for a long while consulted this able physician who after careful examination and many questions realized that the pain should have its origin in the seventh nerve of the cheek He had it cut by Mr Louis a surgeon and since this operation the patient has enjoyed perfect health

Viellard and Dussans (1768) made two unsuccessful attempts to cut the infraorbital nerve and in view of these failures elected not to try a third time Under these rather unfavorable auspices surgical relief of trigeminal pain had its unsuccessful beginning

The facial is believed by some to represent the afferent component of the abducens nerve The acoustic is without a motor root The five remaining somites are associated with the glossopharyngeal and vagus nerves The glossopharyngeal being the nerve of the first gill cleft and in closer relation to the cephalization process is more influenced by the coincident changes than the nerves of the more caudal gill clefts Through the palatine lingual and petrosal nerves the glossopharyngeal is carried to the most rostrad part of the animal The spiracle which lies anterior to the first gill cleft is associated with the facial nerve while the vagus a multiple or compound nerve innervates the remaining four or five gill clefts to serve both visceral motor and sensory functions in its far flung domain

In considering the comparative anatomy it is of interest to compare the arrangement found in water and in land animals since the change from aquatic to terrestrial life brought a distinct rearrangement but with the retention of certain fundamental functions Of particular interest are those changes coincident with the suppression of the lateral line organs—both the nerves and their special endings the neuromasts—and the further development of a new organ of special sense associated with the acoustic the organ of hearing and the vestibular mechanism

The acoustico lateral line develops in the head region from the ganglionic crest It is formed between the trigeminal and the facial ganglia together with the dorso lateral placodes part of which give rise to the acoustic The rostrad part retains its relation with the facial nerve while the caudal extension becomes secondarily associated with the vagus The rostrad portion consists of three primary divisions which are in close relation to the three trigeminal divisions the superficial ophthalmic of the facial with the superficial ophthalmic of the trigeminal supplies the dorsal head region the second division of the facial the buccal is accompanied by the maxillary and the third the external mandibular is accompanied by the mandibular division

With the assumption of terrestrial life the lateral line system together with the neuromasts and their associated ganglia is entirely lost Of the branches of the facial the superficial ophthalmic the buccal and the external mandibular disappear com

is removed The ophthalmic follows closely the shifting of the optic vesicle to which it is related The maxillary ramus does not appear until after the mandibular thus indicating its later development The central processes enter the brain stem at the pontine flexure forming a descending and to a lesser extent an ascending tract Thus in its embryological development from the ganglionic crest the gasserian ganglion follows the general development of the afferent spinal system

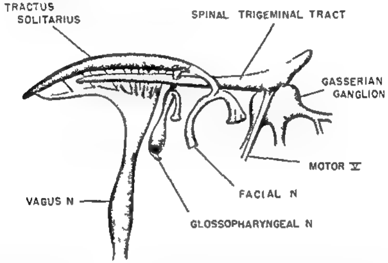


Fig 8 Schematic drawing of a reconstruction of the trigeminal facial glossopharyngeal and vagus nerves showing the trigeminal tract and the tractus solitarius (Human embryo 10 mm Huber collection no 3) Modified after Keibel and Mall Courtesy J P Lippincott Co Philadelphia

In the head region the segmental arrangement found in the lower forms is obscured by the rapid and fleeting changes coincident with cephalization The only definite segments remaining are those connected with the first myotome and oculomotor nerve the second myotome and the trochlear nerve and the third myotome with the abducens and the ocular muscles with which these nerves are connected While some ambiguity still remains concerning the exact number of somites and their afferent and efferent components it is generally accepted with certain reservations that the ophthalmic profundus and the oculomotor belong to the first and the maxillo mandibular the trochlear and the abducens to the second and third myotomes

like manner, the hyobranchial musculature, so prominent in fishes, is diminished in the amphibia, with a consequent diminution in the hyomandibular division In mammals the platysma

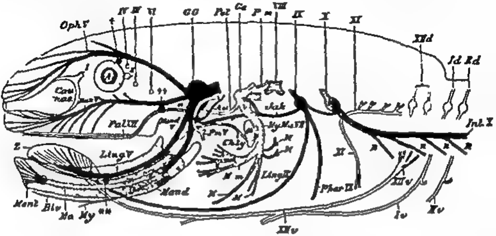


Fig 10 Cerebral nerves in amniota *Cav nas* olfactory organ *A* eye *Oh* tympanoeustachian passage *Mand* mandible *Z* tongue *I,* olfactory nerve *II* optic nerve *III* oculomotor nerve *IV,* pathetic (trochlear) nerve *VI* abducent nerve *V* trigeminal with its three branches the ophthalmic *(Oph V)* maxillary *(Max V)* and mandibular *(Mand V)* the last named dividing into a mandibular in the narrower sense *(Ma)* and a lingual *(Ling V)* The latter is connected with a motor portion *(P m V)* and with the chorda tympani branch of the facial *(Ch ty)* *Ment* branches to chin *Biv My* motor branches which supply the ventral belly of the biventer and the mylohyoid muscles *Au* auriculotemporal branch *VII* facial *Ge* geniculate ganglion *Pet* major superficial petrosal nerve which arises from the sensory portion of the facial and extends forwards beyond the sphenopalatine ganglion (††) as the palatine *(Pal VII)* *Ch ty* chorda tympani part of which in Mammals extends through the middle ear *(Oh)* *Hy Ma VII* main (hyomandibular) trunk which in Primates gives rise to the plexus *(Mim)* for the facial muscles *M M* branches to the muscles of the ear and to the visceral muscles *P im* intermediate portion of facial *VIII* auditory nerve *IX* glossopharyngeal *Ling IX* lingual and *Phar IX* pharyngeal branch *Jab* anastomosis of Jacobson connecting the glossopharyngeal and facial nerves *X* vagus *Int X* intestinal branch with its further subdivisions *R R R R XI* spinal accessory *XIIv* hypoglossal *XIId* its vestigial dorsal roots *Id IId* and *Iv IIv* dorsal and ventral roots of the first two spinal nerves *Ganglia derived from the sympathetic* † ciliary †† sphenopalatine which is connected with the facial by the superficial petrosal nerve * otic connected with the facial and glossopharyngeal by the anastomosis of Jacobson ** submaxillary perforated by the chorda tympani nerve Robert Wiedersheim (1907) Courtesy Macmillan and Co Ltd London

pletely in the adult and are found only in the embryo of selachians and aquatic amphibia These ganglia are thought by some to have united with the gasserian ganglion but of this there is considerable doubt Only three divisions of the aquatic facial remain in terrestrial animals—the palatine (great superficial petrosal) the internal mandibular (chorda tympani) and the hyomandibular (the motor seventh) These three divisions have undergone changes in the animal scale commensurate with the importance of their function The chorda tympani, the palatine and the nervus intermedius for example are prominent in the anteater in which taste on the tongue is well developed but are only rudimentary in birds in which taste is minimal In

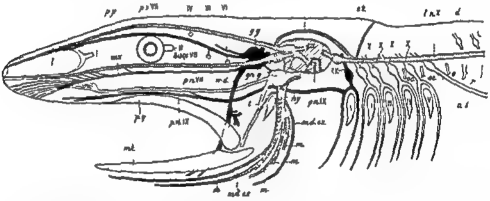
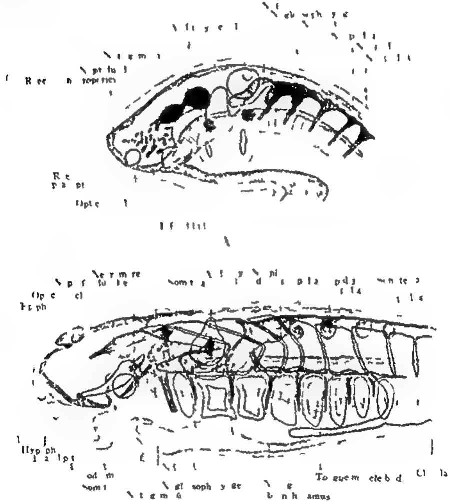


Fig 9 Cerebral nerves in fish *mk c* Meckel s cartilage *ol o,* olfactory organ *p q* palatoquadrate *s* spiracle *I V* branchial clefts *I II III IV VI* the first second third fourth and sixth cerebral nerves *Black*—The trigeminal (Vth nerve) *g g* Gasserian ganglion *m d* mandibularis *mx* maxillaris *op p* ophthalmicus profundus *Oblique shading*—The lateralis system and its centre *(t a)* the tuber acusticum *bucc VII* buccalis branch of VII *md ex* external mandibular branch of VII *l n X* lateralis nerve with its supra temporal branch *(s t)* and its commissural connection *(c)* with op s VII ophthalmicus superficialis of *VII VIII* auditory nerve *Dotted*—The facialis proper *VII* including *c t* chorda tympani *gn g* geniculate ganglion *hy* hyomandibularis with its motor branches *m m m p n VII* palatine *Dark gray*—The glossopharyngeal *(IX)* with its pre and post branchial branches and its palatine nerve *(p n IX)* anastomosing with the palatine branch of VII (Jacobson s anastomosis) *White*—The vagus X *l* the branchial nerves ganglionated and forking over clefts *II V v n X* visceral nerve *oc* spino occipital nerves *d r* and *v r* the dorsal and ventral roots of the first two spinal nerves · Robert Wiedersheim 1907 Courtesy Macmillan and Co Ltd London

division while in petromyzon, the separation of the two is essentially complete This dual origin of the components which make up the adult mammalian gasserian ganglion is further expressed in the brain stem where two separate bundles are found in the descending trigeminal root with a distinct area between them Even in man the relative position of the two



B

Fig 11 Figures showing dual origin of gasserian ganglion A A diagram of the head of Petromyzon at a stage when two gill clefts are open and the neural crest is segmented into the anlages of the cranial ganglia From the left side The dorso lateral placodes are indicated by vertical and horizontal cross lines the epibranchial placodes by oblique lines B A diagram of the head of Petromyzon at a later stage when all the cranial nerves are to be recognized J B Johnston *Nervous System of Vertebrates* 1906 Courtesy Blakiston Co McGraw Hill Co New York

and the facial muscles derived from it though branchial musculature become striate and voluntary muscles nevertheless they maintain their primitive visceral innervation through the motor facial Because of the important role of the facial muscles of expression and the intricate and delicate movements of the lips associated with speech the hyomandibular or motor division assumes greater importance becoming the dominant part of the facial nerve

The course of the internal mandibular (the chorda tympani) is greatly modified by the development of the organ of hearing The internal mandibular branch of the facial passes along the articulation between the articular and the quadrate bones these reduced primary jaw elements are invaginated and modified within the middle ear cavity to form the malleus and incus yet the primitive relation of the nerve to these bones is maintained Thus the circuitous course of the chorda tympani between the malleus and incus becomes understandable

It is a fundamental biological principle that irrespective of any change that may take place in a given structure in the course of its development the primitive nerve association always remains indicating the original relationship Thus, the innervation of the stapedius muscle of the middle ear derived from the dorsal portion of the deep constrictor of the hyomandibular arch is supplied by the hyomandibular motor facial And since a part of the ear in its development is also derived from the mandibular arch which forms the malleus and the tensor tympani muscle originally part of the adductor mandibulae the latter retains its primitive innervation from the mandibular division of the trigeminal nerve

The afferent portion of the trigeminal nerve is made up of two primary ganglia—the ganglion of the ophthalmic profundus and the ganglion of the maxillo mandibular (see Fig 11) The ophthalmic has a more rostral position and since it did not unite with its motor component but retained the primitive separation of afferent and efferent fibers it was able to shift its position caudad to join the ganglion of the maxillo mandibular to form a single ganglion In some of the amphibia the primitive separation of the ganglion is still indicated by a slight

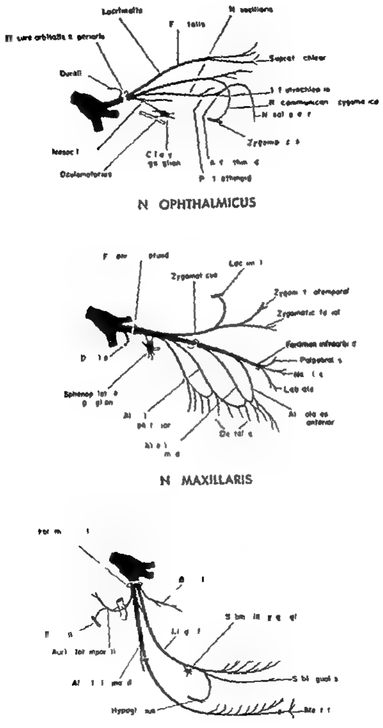


Fig 13 Schematic drawings of ophthalmic maxillary and mandibular divisions and their branches

groups of fibers in the descending tract remains—the ophthalmic retaining a more ventral position and the maxillo mandibular a more dorsal position though the fibers of both are grouped together in a single unit In some forms the ophthalmic takes a darker stain suggestive of a different character of the neurons

The ophthalmic is concerned primarily with somatic sensation extending over the most rostiad portion of the animal serving the nose and the top of the head in its exploratory and searching functions As has been aptly said the animal noses his way along in the world a function which in the higher forms has been taken over by the hand and the median nerve

Since the ophthalmic division arose in the paraxial dorsal mesoderm it supplies the overlying ectoderm maintaining continuity of innervation with the *dorsal* primary divisions of the spinal nerves and the ophthalmic from the tip of the nose to the tip of the coccyx (see Fig 12)

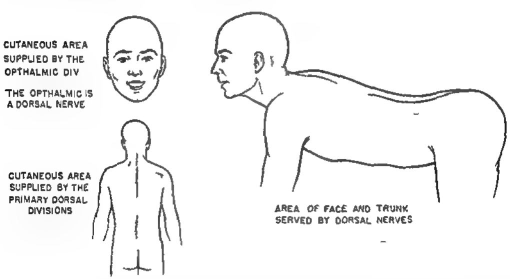


Fig 12 The cutaneous innervation of the face like that of the trunk consists of dorsal and ventral nerves serving a continuous area from the forward exploring tip of the nose to the tip of the coccyx In the frog the descending ophthalmic fibers extend into the lumbar segments Secondary neurons establish reflex connections with both cervical and lumbar segments

The cutaneous area supplied by the mandibular division of the trigeminal is in direct continuity with *ventral* primary divisions

the oculomotor and trochlear nuclei leading Weinberg to the view that they serve at least in part a proprioceptive function for the eye muscles as well as the muscles of mastication

The ratio of the number of cells to muscle spindles and fibers corresponds to the proportion usually found carrying proprioceptive sense which according to Sherrington, is 35 per cent In further support of an afferent function is the absence of pyramidal connections since pyramidal connections would be expected were the mesencephalic root motor Johnston has shown that in all forms studied the fibers are connected with the sensory and not with the motor root and are widely separated from the motor fibers He states that in the 13 5 mm human embryo the mesencephalic root of the trigeminus is connected with the sensory and is clearly not connected with the motor root or nucleus but is widely separated from them

Weinberg s thorough comparative study of the mesencephalic root led him to the following general conclusions

> 1 The mescencephalic root may be conceived as a part of the proprioceptive system for the muscles of mastication and probably for the eye musculature reaching the latter structures via the oculomotor and trochlear nerves
>
> 2 The primitive position of the mesencephalic nucleus is in the region of the optic tectum and transmits deep sensibility from the muscles to the mesencephalic and metencephalic regions
>
> 3 In the course of phylogenetic development the elements of the system migrated toward the source of their greater stimulation and lie in higher vertebrates much more caudal and ventral than their original position in the dorsal part of the midbrain

The trigeminal motor root is visceral The efferent fibers arise from a nuclear mass somewhat more lateral than the more caudal visceral nuclei of the facial glossopharyngeal and vagus nerves The fibers emerge directly and do not assume the centrally directed and then lateral course characteristic of the visceral column in the spinal cord and the other visceral cerebral nerves The more lateral position of the nucleus in the lower forms is at

Thus while the skin immediately adjacent to the area of the ophthalmic is supplied by the primary *dorsal* division of the second cervical segment, the immediate adjacent area of the mandibular division is served by the primary *ventral* division of the second cervical The second cervical segment in its primary dorsal and ventral divisions thus is adjacent and to a degree overlaps the trigeminal area a point to be taken into account in some of the more recent considerations of trigeminal trigger areas and their presumed relation to the second cervical segment

The trigeminal serves both somatic and visceral functions It supplies part of the head the face and the nasal and oral cavity—but only that part of the oral cavity which embryologically is ectodermal in origin and anterior to the bucco pharyngeal membrane Through the mesencephalic root it conveys proprioceptive impulses from the muscles of mastication and since these are visceral in origin this afferent function is visceral

The mesencephalic root and nucleus of the trigeminal nerve have intrigued many workers In general two views have been held one that the cells are motor supplying fibers to the motor root—van Gehuchten (1895) Cajal (1896) and Castaldi (1926)—and the other that the cells are afferent carrying proprioceptive impulses for the muscles of mastication—Johnston (1909) Edinger (1908) Willems (1911) Kosaka (1912) and more recently Weinberg (1928) Johnston considered the cells as ganglion crest cells included within the neural tube and pointed out that they are similar in size form and structure closely resembling the cells of the gasserian ganglion The cells are both bipolar and unipolar having coarse peripherally directed dendrites and centrally directed axones The arrangement of the Nissl granules resembles that in spinal ganglion cells Myelinization of the processes occurs at a different period than that of the motor fibers arising from the trigeminal motor nucleus Furthermore the cells lie lateral and dorsal to the sulcus limitans in the alar plate a position recognized as afferent in function The cells are found throughout the greater part of the midbrain and pons According to Weinberg their frontocaudal extension is about 25 mm The more rostrad extension of the cells of the mesencephalic root places them close to and even scattered within

divides one division passing in front and the other behind the slit The division in front and the branches derived from it are afferent called pretrematic, the division and its branches behind the slit are both afferent and efferent and are designated postrematic Applying this general biological division to the maxillo mandibular and facial nerves, we find that the maxillary division passes in front of the gill slit and therefore is pretrematic and afferent while the mandibular which passes behind, is postrematic both afferent and efferent The ophthalmic lies more rostrad and is not associated with a gill slit

The palatine and the internal mandibular or chorda tympani of the facial pass in front of the spiracle and are therefore pretrematic and afferent while the hyomandibular is postrematic and consequently both afferent and efferent Some however, believe the chorda tympani to be postrematic and to pass behind the gill slit in which event it would carry both afferent and efferent fibers

A consideration of one of the functions of the facial glossopharyngeal and vagus throughout the vertebrate series indicates that they are concerned with taste Taste buds are present in fishes over the head region in the mouth the gills and the pharynx—and in some forms such as the catfish not only over the head but also over the greater part of the body On whatever part of the surface they are located with the exception of the gill region of the pharynx which is supplied by the glossopharyngeal and vagus the taste buds are served by the facial nerve The facial nerve thus supplies taste buds in the ectoderm whereas the glossopharyngeal and vagus supply the buds of the mucous membrane In man the area within the mouth served by the facial is ectodermal in origin

The palatine derived from the geniculate ganglion becomes in man the great superficial petrosal nerve This is joined by fibers from the tympanic plexus arising from Jacobson s nerve of the glossopharyngeal to form the vidian which passes through the sphenopalatine ganglion without synaptic interruption to supply afferent fibers to the soft palate and fauces The chorda tympani—internal mandibular of the lower animals—reaches the anterior two thirds of the tongue via the lingual nerve of

tributable to the influence of the impulses from the trigeminal sensory nuclei and its more frontal position is due in part to those impulses reaching it from the mesencephalic root

The motor cells of the visceral cranial nerves are a direct cephalic extension of the visceral motor column of the spinal cord lateral horn As in the cord this column occupies a more lateral position than the somatic motor column which in the brain stem is represented by the hypoglossal abducens, trochlear and oculomotor The hypoglossal more nearly resembles a spinal nerve having a transitory dorsal root and ganglion on one of the hypoglossal rootlets occasionally seen in the adult and known as Froriep s ganglion Even in some fishes and amphibians the hypoglossal nerve *has been drawn up in the brain stem by the* neurobiotactic influence of the trigeminal facial glossopharyngeal and vagus with which it is functionately intimately associated

While the visceral motor column primarily supplies involuntary muscles the cerebral visceral nerves are concerned with branchiomeric mucles derived from the gill slit Since the gill cleft muscles are developed from the region of the pharynx they belong to the musculature of the alimentary canal are consequently derived from the splanchnic mesoderm and in origin therefore are smooth muscles In the evolutionary process however they have become striate and voluntary and have taken on new functions yet their primitive visceral innervation has been maintained

The glossopharyngeal may be taken as *the prototype of the* nerves supplying the branchial arches the remaining four or five arches caudal to the glossopharyngeal are taken over by the vagus In addition there are two modified gill slits rostrad to that of the glossopharyngeal One of these the spiracle lies somewhat dorsal as well as rostrad and through it water enters to make its egress by way of the more caudally placed gill slits The other the mandibular arch lying ventral and rostrad by fusion in the midline has given rise to the mouth The former the hyoid arch is served by the facial nerve whereas the mandibular is supplied by the maxillo mandibular nerves

As each nerve with its ganglion reaches a gill slit the nerve

through the geniculate ganglion, the nervus intermedius and the petrosal ganglion of the glossopharyngeal Embryologically, not only in the lower forms but also in man the palatine and chorda tympani fibers can be followed as outgrowths of the geniculate ganglion and are entirely separate from the trigeminal with which they become associated late in the course of ontogenetic development

Of the four autonomic ganglia associated with the trigeminal nerve only the ciliary ganglion is found in the aquatic forms thus phylogentically the oldest the sphenopalatine otic and submaxillary appear with the assumption of terrestrial life The circular fibers of the iris and the ciliary muscle are supplied by the ciliary ganglion the lacrimal gland the mucosa the vessels of the nasal cavity and the palate are served through the sphenopalatine ganglion the parotid gland through the otic ganglion and the submaxillary and sublingual through the submaxillary

The cranial autonomic ganglia arise from the ganglionic crest and the neural tube in the same manner as all other autonomic ganglia *i e* by migration along the ventral and in some forms the dorsal roots

The ciliary ganglion is formed by cells which have migrated with the oculomotor fibers The remaining ganglia follow the afferent fibers of the facial and glossopharyngeal nerves By following the dorsal root in their migration they revert to a more primitive pattern In amphioxus these effector cells emerge exclusively along the dorsal roots in some amphibia they follow both the dorsal and ventral roots Their course is of interest because autonomic cells being effector are derived from the basal plate of the neural tube are therefore motor and consequently would presumably emerge with the ventral roots Kuntz (1913) has shown however that in the human and other embryos they are associated in their migration with both the ventral and the dorsal roots

The cells of the autonomic ganglia are at first diffuse both morphologically and in functional effect Only later do they become arranged into definite ganglia In some of the lower forms the ciliary ganglion cells are scattered along the nerve of origin

the trigeminal to supply taste buds in that area The central arms of these fibers from the geniculate ganglion reach the brain stem as the nervus intermedius to enter the tractus solitarius

The posterior third of the tongue and fauces are supplied by the distal processes from the petrosal ganglion of the glossopharyngeal the central arms like those of the nervus intermedius enter the tractus solitarius to terminate in the nuclei associated with this tract The fibers serving taste from both the intermedius and the glossopharyngeal terminate in the more rostral portion of the tract whereas the fibers from the vagus reach the more caudal part being primarily concerned with general visceral afferent impulses rather than with the special afferent function of taste (see Fig 14)

The comparative anatomy of the lower animals as well as of the higher forms thus indicates that the pathway of taste is

MODERN CONCEPT
NERVES SERVING GUSTATORY FUNCTION

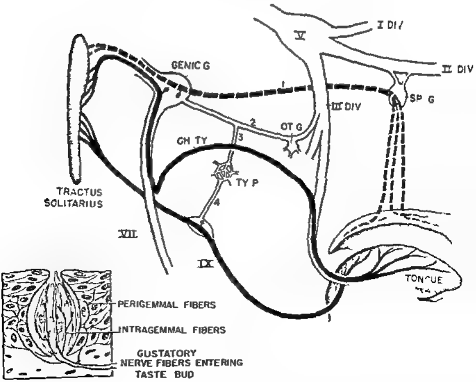


Fig 14 Schematic drawing showing nerves serving gustatory function

In terrestrial animals a ganglion appears on the palatine nerve—the sphenopalatine ganglion It is an autonomic ganglion made up of multipolar cells upon which the preganglionic cranial autonomic fibers end Afferent and postganglionic sympathetic fibers pass through or beside the ganglion without interruption While the palatine nerve of the glossopharyngeal is no longer present as a distinct branch the glossopharyngeal, through Jacobson s nerve continues to supply the same general region with an added communicating branch between the petrosal and jugular ganglia of the glossopharyngeal and vagus nerves Thus in terrestrial animals the sphenopalatine ganglion is the crossroads for the distribution of fibers from the vagus the glossopharyngeal and the facial nerves as well as the cranial and spinal autonomic system

Yagita (1914) has shown that section of the great superficial petrosal nerve leads to chromatolysis of about 8 per cent of the cells of the geniculate ganglion Thus it is probable that the palatine nerve of aquatic animals now the great superficial petrosal like the chorda tympani is concerned with taste, though in addition it carries important efferent fibers

The sphenopalatine ganglion lies close to the maxillary nerve whence two short branches pass to the ganglion To this it contributes only a few fibers the majority passing through or beside the ganglion to continue with the palatine nerves (see Fig 16)

The great superficial petrosal nerve from the geniculate ganglion is joined by the great deep petrosal from the carotid plexus carrying unmyelinated fibers from the cervical sympathetic to form the vidian nerve It also receives a twig from Jacobson s nerve of the glossopharyngeal through the tympanic plexus

The great superficial petrosal contains small myelinated and unmyelinated vasodilator fibers of 2 to 4 microns which terminate in the sphenopalatine ganglion and in addition large myelinated fibers which bypass the ganglion to continue into the palatine nerves It is believed that some of the large myelinated fibers serve taste

Chorobski and Penfield (1932) in a most carefully controlled experiment demonstrated that preganglionic efferent fibers derived from within the brain stem pass *via* the nervus intermedius

forming a number of small ganglia in the orbit rather than a single ciliary ganglion, a pattern curiously found in the orbit of the horse

The ciliary ganglion receives its preganglionic motor component from the cells of the Edinger Westphal nucleus, the fibers pass with the oculomotor to terminate in the ganglion and from this the postganglionic fibers continue as the short ciliary nerves to the constrictor of the iris The cilio spinal nuclei in the cervical cord send their preganglionic fibers through

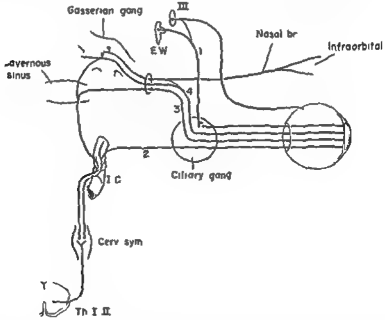


Fig 15 Schematic drawing showing neural components of ciliary ganglion

the cervical sympathetic chain to terminate in the superior cervical ganglia Thence as postganglionic fibers they pass *via* the cavernous sinus to the nasal branch of the ophthalmic and to the ciliary ganglion which they traverse without synapse to supply the dilator fibers of the iris The vasomotor fibers reach the posterior aspect of the ciliary ganglion from the internal carotid and also pass through the ganglion without synapse

In aquatic vertebrates the palatine nerve passes rostrad from the geniculate ganglion no sphenopalatine ganglion is present A similar nerve supplying approximately the same area is the palatine nerve of the glossopharyngeal These two palatine nerves presumably carry taste

In terrestrial animals a ganglion appears on the palatine nerve—the sphenopalatine ganglion It is an autonomic ganglion made up of multipolar cells upon which the preganglionic cranial autonomic fibers end Afferent and postganglionic sympathetic fibers pass through or beside the ganglion without interruption While the palatine nerve of the glossopharyngeal is no longer present as a distinct branch, the glossopharyngeal, through Jacobson s nerve continues to supply the same general region with an added communicating branch between the petrosal and jugular ganglia of the glossopharyngeal and vagus nerves Thus in terrestrial animals the sphenopalatine ganglion is the crossroads for the distribution of fibers from the vagus the glossopharyngeal and the facial nerves as well as the cranial and spinal autonomic system

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of Wrisberg bypassing the geniculate ganglion to enter the great superficial petrosal nerve They join the internal carotid nerve forming synapse with scattered ganglion cells just before they reach the internal carotid artery Stimulation of the great superficial petrosal nerve induces vasodilatation of the pial vessels Sweet and White (1953) stimulating the great superficial petrosal

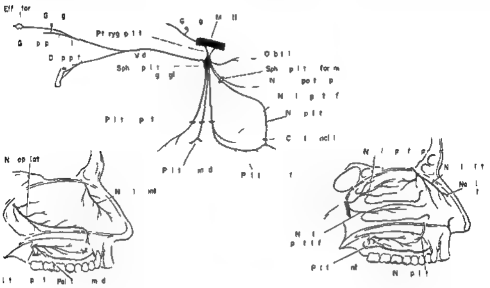

Fig 16 Distribution of nerves associated with the sphenopalatine ganglion

nerve as it crosses the floor of the middle fossa during operations for trigeminal neuralgia found pain to be referred to the ipsilateral eye ear and adjoining parts of the head

The components of the great superficial petrosal nerve are of anatomical and clinical interest There are two major groups of fibers efferent (vasodilator and secretory) and afferent

Efferent fibers The cell bodies lie in the brain stem close to the facial nucleus and leave with the nervus intermedius as preganglionic fibers to pass through the geniculate ganglion *without* synapse terminating (*a*) around cells in the sphenopalatine ganglion as vasodilator and secretory fibers to the soft palate roof of the mouth pharynx and nose and (*b*) about cells on the internal carotid as vasodilator fibers to the pial vessels (Chorobski and Penfield)

Afferent fibers The cell bodies lie in the geniculate ganglion

the peripheral arms pass *via* the great superficial petrosal and vidian through the sphenopalatine ganglion *without* synapse into the peripheral distribution of fibers around the sphenopalatine ganglion (some of these probably serve taste) In addition afferent fibers enter the cranial cavity *via* the internal carotid The central arms from the cells in the geniculate ganglion enter the brain stem *via* the nervus intermedius

It is interesting that Chorobski and Penfield noted effector fibers in the nervus intermedius and that after isolated section of the nervus intermedius Furlow (1942) found diminution of secretion from the sublingual and submaxillary glands Thus the afferent root of the facial nerve carries both afferent and effector fibers

From a clinical standpoint and especially in a study of facial pain the anatomy of the sphenopalatine ganglion merits detailed consideration In it the cranial autonomic fibers make their synapse in addition, it is an important center for the passage of fibers from the geniculate ganglion the petrosal ganglion of the glossopharyngeal and the jugular ganglion of the vagus as well as of postganglionic fibers from the cervical sympathetic ganglion The sphenopalatine ganglion thus is a network of neural components serving an important area of the face The following fibers can be traced in relation to this ganglion

Afferent From the gasserian ganglion and maxillary nerve to the palatine nerve serving somatic sensation from the geniculate ganglion to the palatine nerves probably serving taste from the petrosal ganglion of the glossopharyngeal to the palatine nerves serving taste These are large myelinated fibers which pass by or through the sphenopalatine ganglion without synapse

Effector The cranio autonomic *via* the great superficial petrosal and *via* the short branch of the maxillary to form a synapse in the sphenopalatine ganglion—vasodilator fibers from the superior cervical internal carotid and cavernous sinus *via* the great superficial petrosal—vasoconstrictor and secretory fibers

The fibers associated with the sphenopalatine ganglion are

1 Pharyngeal to the mucous membrane of the roof of the pharynx

2 Superior posterior nasal to the posterior superior portion of the outer wall of the nasal cavity upper and middle turbinate

3 Nasopalatine crossing the roof of the nasal chamber to supply the vomer and septal cartilage through Scarpa s foramen to the anterior part of the hard palate there communicating with the anterior palatine

4 Anterior palatine to the mucous membrane of the soft and hard palate with a branch to supply the posterior part of the inferior turbinate and the middle and inferior meatus

5 Middle palatine to the mucous membrane of the soft palate, uvula and palatine tonsil

6 Posterior palatine to the mucous membrane of the tonsil soft palate and uvula

7 Orbital to the periosteum of the orbit

The finer anatomical studies on the formation and neural connections of the sphenopalatine by Sheldon (1909) Fenton and Larsell (1928) and Larsell and Burns (1931) have laid a basis for an understanding of this important pathway and may help to clarify some of the atypical forms of neuralgia with which the clinician is concerned

CHAPTER III

PHYSIOLOGY OF THE TRIGEMINAL NERVE

The cutaneous sensory area supplied by the trigeminal nerve follows an almost constant pattern with slight deviation along the border adjacent to the second cervical dermatome. The greatest variation is on the side of the face: the area of distribution in some instances follows fairly closely the line of the mandible, while in others it reaches upward for a considerable distance onto the cheek. Slight deviations along the posterior border over the scalp have also been noted. We have never, however, found any alteration along the midline, with extension into the opposite trigeminal area. The only significant deviations, then—and these are slight—are to be found adjacent to the second cervical dermatome in both its primary dorsal division over the cranial vault and in the primary ventral division over the cheek.

Innervation of the Cornea. The innervation of the cornea is of special interest, since here but one form of sensation is involved, namely pain. Many studies of corneal innervation have been made—notably those of Dogiel (1890) and Cajal (1909) half a century ago, and more recently the detailed investigations of Sarah Tower (1943), who showed it to consist of a plexiform ramification of free nerve terminals except around the sclero-corneal junction, where both Krause's end bulbs and cold sensibility are added. Cajal described free nerve terminals in the intercellular cement substance from the deepest to the most superficial parts of the epithelium. The nerve fibers are myelinated as they enter the corneal connective tissue, but the myelin sheath is lost as they pass from the periphery to the center of the cornea. An unmyelinated plexus is then found in the cement substance, characterized by intricate overlapping and interlocking with wide distribution of a unit neuron terminal. These fibers

2 Superior posterior nasal to the posterior superior portion of the outer wall of the nasal cavity upper and middle turbinate

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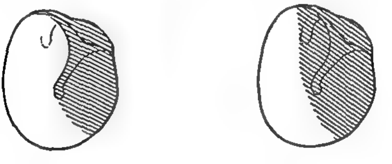
confirm Marshall's conclusions. Since, however, it is impossible, in a differential section within the dorsal root, to say with certainty which particular fibers have been severed, the problem remained open until Rowbotham (1939), by intracranial section of the maxillary division at the foramen rotundum, demonstrated that in no instance did the sensory loss reach the cornea; conversely, when the ophthalmic division was sectioned intracranially, the entire cornea was rendered insensitive. Thus the generally accepted view of the innervation of the cornea was reaffirmed.



A B

Fig. 18. Variations in the trigeminal innervation of the tympanic membrane.

Innervation of the External Auditory Meatus and Tympanic Membrane. The trigeminal innervation of the external auditory meatus and eardrum, in our experience, has been variable. The most constant loss of sensation on section of the nerve was on the anterior wall of the external auditory meatus, but the area affected was variable and no definite line of demarcation could be established with any constancy from case to case. Similar results were obtained in testing sensation of the tympanic membrane, which is supplied solely with pain fibers. Touching the eardrum with a hair caused the patient promptly to withdraw his head and at the same time a sudden burst of sound was heard. Here again, no definite area could be outlined with any consistency. As has been stated (p. 38), in view of the embryological development of the ear, in which the trigeminal, the facial, the glossopharyngeal and the vagus nerves all participate, with consequent overlap, definitive areas attributable to any one nerve could hardly be expected.

penetrate the eyeball and extend in the sclera to enter the cornea circumferentially around the sclerocorneal junction (Tower) They arise from the long ciliary nerves derived from the nasociliary branch of the ophthalmic division

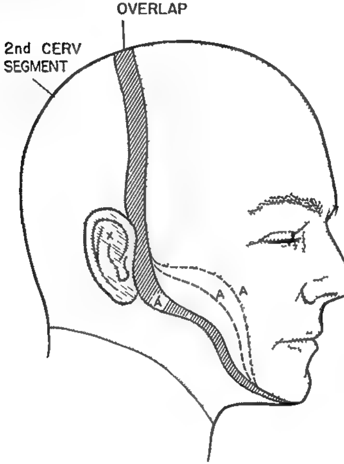


Fig 17 Lightly stippled area shows somatic cutaneous distribution of the trigeminal nerve A A and A indicate variable area supplied by the trigeminal and second cervical nerves Dark shaded area indicates second cervical segment Dark diagonal shading outlines the approximate area of overlap The ear contains variable components of the trigeminal facial glossopharyngeal and vagus nerves and the second cervical segment

As a result of studies of corneal innervation in Jefferson s fractional root sections Marshall (1931) concluded that the upper half of the cornea was supplied by the ophthalmic while the lower half was innervated by the maxillary In repeated examinations after subtotal and differential resection we were unable to

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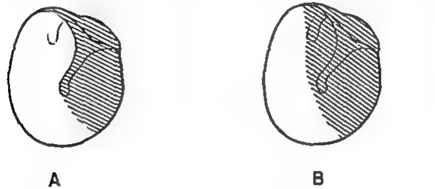

Fig 18 Variations in the trigeminal innervation of the tympanic membrane

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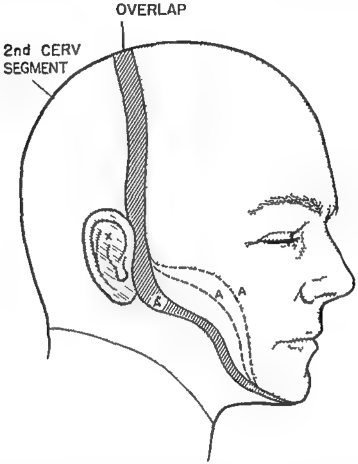

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Davies (1907) made the interesting observation that headaches never occur on the side of the operation but are confined entirely to the normal half of the cranium Carmichael and Woollard (1933) commented on this matter but their material did not permit of a definite conclusion We regret that our observations have not included this point

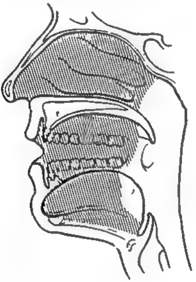
Deep Pain Sense After Trigeminal Dorsal Root Section Considerable stress has been laid on the somatic sensory function of the facial glossopharyngeal and vagus nerves Somatic sensory representation in these branchial nerves has gradually decreased The residual sensory components however are worthy of study in view of the more recent concepts concerning trigger zones and the stress placed on the cervical sensory areas bordering on the trigeminal zone

The problem of deep sensibility within the trigeminal areas has been under investigation for a number of years Davis (1923) Frazier (1928) Carmichael and Woollard and Wakeley and Edgeworth (1933) have studied the problem In spite of much research there is no unanimity of opinion though the weight of evidence has favored the view that deep pressure pain sense is mediated through the facial nerve

Davis measured deep pressure pain in fourteen patients with complete trigeminal dorsal root section In all this sense was retained and the values on the operated and unoperated sides were essentially identical as measured by the Cattell algometer If however in addition to trigeminal dorsal root section the facial nerve was paralyzed there was no deep pain *response* to pressures up to 15 kilograms (see Fig 20) Frazier confirmed Davis s observations and found further that sympathetic block after the trigeminal dorsal root had been severed did not alter the pressure relationships

Carmichael and Woollard found that if the head were held firmly on a rigid support so that the neck muscles did not come into action deep pressure pain was lost in the presence of total anesthesia in the trigeminal area but if the *same* patient were

Innervation of the Buccal and Nasal Mucous Membranes Following trigeminal section the sensory loss in the mucous membrane of the mouth was found to include the roof and floor the tongue as far as the circumvallate papillae the cheek lips and upper and lower gums, and the hard palate The posterior limit over the soft palate and the anterior and posterior palatine arches was variable In some instances the uvula was insensitive in others sensation was present There were no sensory changes in the tonsils or the posterior palatine arches The mucous membrane within the nose was insensitive When a cotton swab was introduced no alteration in the lacrimal reflex occurred



THE INTRANASAL AND INTRAORAL
FIELD OF THE TRIGEMINAL NERVE

Fig 19 The intranasal and intraoral field of the trigeminal nerve

Innervation of the Dura Mater Each division of the trigeminal gives a twig to the dura—the recurrent dural branch of the ophthalmic accompanies the trochlear nerve to the tentorium the recurrent maxillary goes to the dura of the middle fossa while the mandibular twig arises outside the skull and re enters through the foramen spinosum with the middle meningeal These trigeminal branches are said to supply the dura but in operations

upon the brain under a local anaesthetic when they could not possibly have been included in the anaesthesia the dura has been found insensitive except along the major vessels and sinuses

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allowed to rest the head on a pillow without rigid support deep pain sense was retained The areas tested however did not include the principal trigeminal regions since most of the readings were taken from the temporal fossa and supraorbital areas with only a few from the infraorbital region and none over the upper or lower lip Furthermore the high pressures used by Davis and Frazier were not attempted for fear of injuring tissues 9 kilograms being the limit

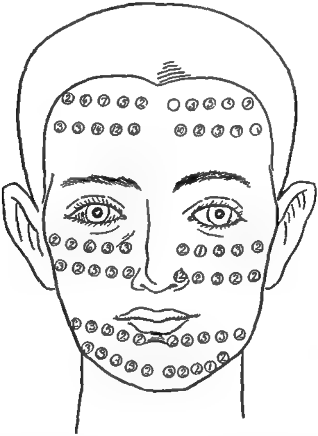

Fig 20 Average readings of the algometer producing pressure pain sensation in ten cases are shown within the circles Reading from left to right in each area the numbers represent the readings on the right and left sides in a given case Figure and legend from Davis 1923 *Arch Neurol & Psychiat* Courtesy American Medical Association Chicago

Another circumstance rendering Carmichael and Woollard s series unsuitable for comparison with the earlier studies was their induction of anaesthesia by alcohol injections into the semi

lunar ganglion a procedure which has been shown to permit leakage of the injected material towards the geniculate ganglion If damage to the cells of the geniculate ganglion had thus been caused the conclusions concerning deep pressure sense would be questionable

In addition to his clinical studies, Davis cut the facial nerve in cats at the stylomastoid foramen and studied histologically the cells of the geniculate ganglion Central chromatolysis of the cells was found but not to the same extent as after section of the chorda tympani which Amabilino (1898) had shown to result in degeneration of four fifths of the geniculate cells

Wakeley and Edgeworth investigated the number of afferent fibers in the facial nerve as it left the stylomastoid foramen In the monkey (*Macacus rhesus*) they found the fiber count in any given animal to be approximately the same on the two sides though considerable variation from one animal to another existed With this information, the facial nerve on one side was cut intracranially central to the geniculate ganglion Four weeks later the fibers were counted on both sides On the normal side 4 782 fibers were found while on the side of the severed nerve only 359 The fibers varied in diameter from 2 to 12 microns on both the normal and cut sides The investigators concluded that the facial afferent fibers at the styloid process served proprioceptive function for the facial muscles Unfortunately they did not support their work with histological studies of the geniculate ganglion nor is it clear that the intact fibers found in the severed facial nerve necessarily served proprioceptive and deep pressure pain functions Their experiment did prove the existence of afferent fibers distal to the geniculate ganglion in the facial nerve at its exit from the stylomastoid foramen The problem would thus appear to require further investigation

In order to eliminate pressure upon the bones of the cranial vault and face yet test pressure pain sense in the soft tissues of the face including the facial muscles the senior author some years ago devised an instrument which would permit pressure upon the tissues of the eyebrow alae nasi and upper and lower lip In these regions there is no overlap from the second cervical segment and the objection raised by Carmichael and Woollard of

pressure upon the back of the head and neck muscles is eliminated

The ends of the instrument clasp the eyebrow, alae nasi upper and lower lip and tongue A set screw is then gradually turned and pressure exerted (see Fig 21) On the normal side pain is severe at 1 kg whereas no pain is induced on the side of dorsal root section though pressure of 4 to 5 kg is applied Since only soft denervated tissues are held between the jaws of the device it has not been felt justifiable to exert more than 4 to 5 kg of pressure Thus tested deep pressure pain sense was found to be lost in anaesthetic areas supplied by the trigeminal after dorsal root section even though a normally functioning facial nerve was present On this basis the conclusion seems warranted that deep pressure sense to the muscles and tissues of the face is served by the trigeminal and not the facial nerve In a few instances however pain was present in the lower lip at pressures of 3 to 5 kg It was never as acute as on the normal side nor

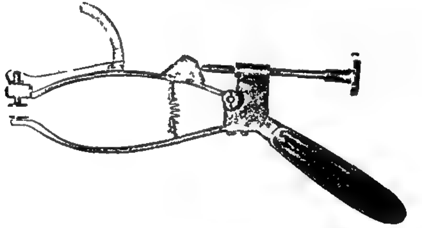

Fig 21 Instrument exerting compressive force between two discs 12 mm in diameter to measure deep pressure sense of the tissues served by the trigeminal nerve

was it correctly localized, being referred to the cheek and angle of the jaw. When deep pressure pain could be elicited in the lower lip at 3 to 5 kg it could also be produced in the tongue. As in the lower lip the pain was not as acute as on the normal side. It was referred to the base of the tongue and could not be localized. The presence of deep pressure pain in the lower lip and tongue in the absence of superficial pain in these instances needs further study. It is possible, as Davis suggested, that deep pain for the tongue may be carried by the hypoglossal nerve, though in the majority tested this certainly was not the case. In no instance could deep pressure pain be produced in eyebrow, ala nasi or upper lip.

As mentioned above (p 59) Ambilino found chromatolysis of 80 per cent of the cells of the geniculate ganglion after section of

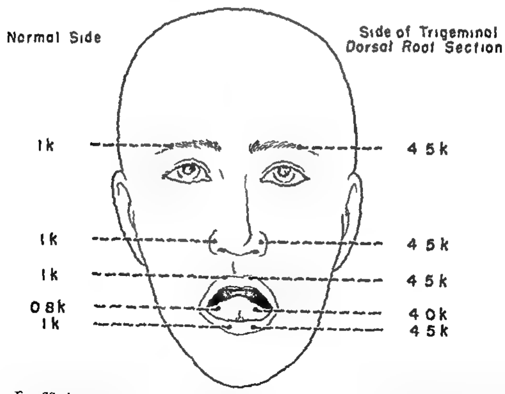

Fig 22 Average readings of compressive force expressed in kilograms applied to eyebrow, ala nasi, upper lip, tongue and lower lip after trigeminal dorsal root section without production of pain. Since the tissues are denervated it seemed unwise to exert greater pressure. *Pain is excruciating at 1 to 2.5 kilograms on normal side*

the chorda tympani and Yagita (1914) 8 per cent after section of the great superficial petrosal nerve Thus only about 12 per cent of the ganglion cells remain to account for the known cutaneous supply about the ear and the cleft between the ear and mastoid, as pointed out by Hunt (1937) The number of cells in the geniculate ganglion to serve deep pressure sense through the facial would appear to be minimal

Principle of Usurpation The so called principle of usurpation of the trigeminal, frequently referred to in comparing the trigeminal and cervical cutaneous areas in ape and man overlooks the finer basic anatomy throughout the vertebrate scale in which the trigeminal remains the somatic afferent nerve of the cranium The ophthalmic and maxillo mandibular subsequently united as a single nerve supply the paleocranium The bony mask covering the brain case and face in the oldest tetrapods both amphibians and reptiles is supplied by the trigeminal Actually usurpation does not enter into the picture The nerve has merely kept pace with the expansion of its domain as the cranial vault has enlarged especially in the frontal region to accomodate the expanding brain as the maxilla has developed from a slender bar in front of the eye with formation of the cheek and as the mandible and mandibular joint have evolved from the derma bar (while the old reptilian joint has assumed its new function in the middle ear) In accord with the well established principle that an innervation once fixed is maintained irrespective of expansion or migration the trigeminal continues to serve its original function The change is in the *area* of the innervated structures One need only compare the skull of an Eocene lemur oid or Old World monkey with the human skull to realize the great expansion of the face and frontal cranial vault belonging to the trigeminal nerve (see Fig 23)

The biological principle of constancy of the primitive inner vation is also observed elsewhere as in the evolution of the facial muscles When in the primitive mammals the bony mask of the face became depressed and pliable skin developed over it the sphincter colli muscles of the neck and throat of reptiles served by the seventh nerve grew forward beneath the skin to the top of the vault and sides of the face sending subdivisions about the

ears forehead, eyes and mouth to form the mimetic muscles The seventh nerve maintained its function in this expansion and further evolution of the original muscles (see Fig 24)

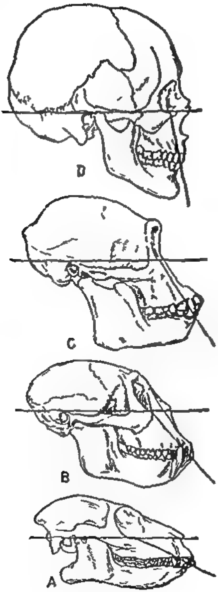

Fig 23 *Gradual expansion of* bony mask and brain case with corresponding increase in trigeminal area Side view of skulls of primates showing progressive shortening of the *muzzle* downward bending of the face below the eyes and forward growth of the chin A Eocene lemuroid B Old World monkey C Female chimpanzee D Man *(B and C after Elliot)* William K Gregory *Our Face from Fish to Man* 1929 Courtesy G P Putnam s Sons New York

Along with these changes when the gill arches no longer broke through to the surface but formed deeper lying structures as the cartilaginous rings of the trachea and bronchi the thyroid and hyoid cartilages their nerves lost in large part their already extremely limited somatic cutaneous distribution and the fibers

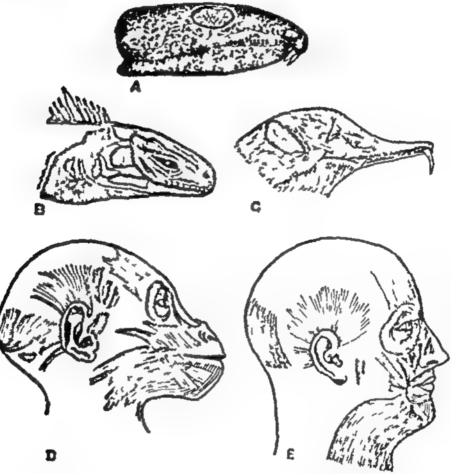

Fig 24 Evolution of sphincter colli muscles into mimetic muscles served by the seventh nerve Origin of the facial muscles of man A Primitive reptile with continuous bony mask covering skull The mask was covered with thick skin without muscles as in the alligator (After Williston) B Modern reptile with an open or fenestrated skull covered with thick nonmuscular skin (From Furbringer modified from Ruge) C Primitive mammal in which the sphincter colli system has grown forward over the face D Gorilla E Man (C D and E after Ruge) William K Gregory *Our Face from Fish to Man* 1929 Courtesy G P Putnam s Sons New York

ned the somatic descending trigeminal tract within the brain
m to serve somatic sensation

With the expanding cranial processes nerves which are not
imarily cranial are drawn into the skull In cyclostomes the
gus lies behind the skull whereas in amniotes both the vagus
d the hypoglossal the latter a cervical nerve, appear in the
ull as cranial nerves Thus with the expansion of the skull and
ce and the suppression of the gill arches together with the
evelopment of a neck the second cervical segment comes to
e along the periphery of the trigeminal area as well as centrally
ithin the cervical cord where it is in juxtaposition to the
igeminal descending root As has been previously stated the
udal extension of the descending tract enabled the trigeminal
establish *direct* reflex connections from the most forward
xploring part of the animal with the neck musculature and in
ne amphibia by extension of some of the fibers of the descending
igeminal tract to the cervical and lumbar segments with the
ore and hind limbs

Motor Innervation The muscles innervated by the motor divi
on of the trigeminal nerve are those derived from the primitive
pper and lower constrictor group of the mandibular arch These
re the muscles of mastication—the temporal masseter external
nd internal pterygoid—and the mylohyoid and anterior belly
f the digastric This last by fixing the hyoid, assists the mylo-
yoid in pressing the tongue against the palate The mylohyoid
y attachment to the median raphe and to the corresponding
nuscle of the opposite side forms the muscular floor of the
nouth the *diaphragma oris* Only rarely when the motor root
has been destroyed have we been able to detect any loss of
tone in the floor of the mouth on the side of the operation Pos
sibly the pull of the opposite muscle through the median raphe
permits sufficient tension to prevent detection of atony on the
affected side

The tongue may show slight ataxia when the mandibular
afferent impulses have been destroyed on both sides in bilateral
operations but this is only temporary Rowbotham has suggested
that there may be proprioceptive fibers in the hypoglossal nerve
as is thought to be true of the oculomotor

The tensor tympani and the tensor veli palatini are supplied by the trigeminal The tensor veli palatini tends to draw the soft palate to one side In some cases this may be barely apparent and brought out only on phonation especially as in a prolonged eh but usually no deviation is seen While the tensor tympani by its attachment near the head of the malleus is in a position to tense the tympanic membrane no disturbance in appreciation of high or low pitched notes has followed operation in our series unless there has been blood in the middle ear

Loss of innervation to the muscles of mastication causes the jaw to deviate slightly on opening with diminished grinding action The patients do not complain however of any difficulty or inconvenience in chewing In unilateral destruction of the motor root the jaw is drawn forward by the normal pterygoid with an accompanying pivotal action at the temporo mandibular joint on the paralyzed side which accounts for the lateral move ment of the jaw The prime function of the temporal masseter and internal pterygoid muscles is to raise the mandible and give it its biting power

Incidentally it is of interest that it was repeated pressure upon the external pterygoid by the enlarging dentary bone which gave rise to a connective tissue sac and finally to the meniscus between the temporal bone and mandible Gaupp (1911) found in a 42 mm embryo of one of the primitive mammals (Perameles) that during the course of its development part of the external pterygoid passed *between* the lower jaw and the temporal bone It was this part of the muscle subjected to continuing pressure across its line of action which ultimately contributed to the formation of the temporo mandibular joint and its meniscus The meniscus has been molded to adjust for the disparity of the articulating surface of the condyle below and the fossa in the temporal bone above The anterior margin of the meniscus is intimately attached to the external pterygoid muscle moving forward and backward with the condyle Gregory (1929) pointed out that this joint and its muscles made possible the mammalian jaw and teeth forming a new and powerful weapon impossible in the reptile which helped the mammal to over run the animal world Another though minor trigeminal contribution to this

joint and in this advance, was the extension of the dura which envelops the maxillary division as it passes through the foramen ovale to form two reinforcing bands one on the anterior and the other on the inner surface of the capsule of the temporo mandibular joint

Trigeminal Reflexes The oculo cardiac or oculo vagal reflex *i e*, slowing of the pulse and lowered blood pressure in response to pressure on the eye depends upon the production of pain We have not felt it justifiable to exert sufficient pressure upon the insensitive eye to determine the presence or absence of this reflex following trigeminal section

Vasomotor and Secretory Functions No vasomotor disturbances have been noted in the skin on the operated side Blushing is unaltered nor have we seen any effect upon sweating Occasion ally the skin appears greasy especially over the forehead and about the nose and upper lip

Gustatory Sense on the Anterior Two Thirds of the Tongue The carefully controlled clinical and experimental studies of taste presented by Inzani and Lussana (1862) and Lussana (1869 and 1871) are models of clarity and accuracy Lussana professor of physiology at Padua was the first to depict accurately the course of taste impressions from the anterior part of the tongue by way of the geniculate ganglion and nervus intermedius to enter the brain stem Magendie (1822) and Bernard (1843) had previously held that this function was served by the trigeminal Still earlier Caldani (1793) had reported a case of so called *spasm cinique* with complete abolition of taste though there was no lesion of the glossopharyngeal and the pain was solely in the distribution of the fifth nerve

Bernard recognized that the chorda tympani from the seventh played a part in gustatory function but held that its role lay in the control of movements within the tongue which placed the gustatory papillae in instant position to receive taste impressions when this movement was lost such impressions were greatly re tarded In other words he looked upon the chorda tympani as serving a special motor function in the transmission of taste and not as a sensory receptor

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Bellingeri (1818) was cited by Lussana as the first to assign to

the chorda tympani a special influence upon taste Alterations of taste in association with facial paralysis were noted by Montault (1831) and also by Bernard whose explanation of such changes is given above

Lussana credited his former teacher Panizza as being the first to recognize that the glossopharyngeal nerve transmitted taste from the tongue and suggested that it be called *the gustatory nerve of Panizza* Biffi and Morganti (1846) fellow students of Lussana assigned taste on the anterior two thirds of the tongue to the chorda tympani and limited the role of the glossopharyngeal to the posterior third

Lussana had access to unusual and striking clinical material One patient on the service of his colleague Renzi proved to have a fairly large tumor beneath the gasserian ganglion which destroyed the trigeminal nerve causing complete anaesthesia of one half of the face including the tongue On testing however it was found that taste was retained on the anterior part of the tongue Another patient with excruciating trigeminal pain was operated upon by Lussana s associate Inzani who sectioned the lingual nerve with the result that not only was sensation completely abolished on the anterior part of the tongue but taste as well In a third case operated upon by a charlatan in the public square the chorda tympani was cut by a long lancet introduced into the external auditory canal The patient suffered intense pain fainted displayed convulsive movements and fell to the ground while the charlatan fled precipitously glad to avoid the indignation of the spectators who numbered several hundred Two years later in 1862 on a visit to his native village where the episode had occurred Lussana was able to examine the patient He found the mouth deviated to one side the left eyelid could not be closed but sensation was normal over the entire face and in the mouth Tests with salt sugar and vinegar showed taste to be lost on the anterior two thirds of the tongue on the operated side but normal on the other side as well as bilaterally over the posterior third

In order to establish experimentally his clinical observations Lussana used dogs which had been trained to recognize taste substances Various nerves were cut separately and in combination

In one animal both glossopharyngeal nerves were severed in another the lingual on one side before its junction with the chorda tympani and on the opposite side after it was joined by the chorda tympani In still another, both glossopharyngeal and both lingual nerves were sectioned Tests were then carried out over a period of a year following the operation

Lussana thus established, on both clinical and experimental grounds that for the anterior two thirds of the tongue taste was carried from the lingual by the chorda tympani and for the posterior third by the glossopharyngeal Biffi and Morganti, a few years earlier, had demonstrated that the chorda tympani is a sensory nerve formed by a portion of the seventh whose fibers enter the brain as the nerve of Wrisberg Lussana s obvious conclusion was that gustatory impressions reached the brain through the seventh and not the fifth as had theretofore been taught

In spite of Lussana s carefully documented protocols and clinical observations Schiff (1869) on less evidence claimed to have traced taste fibers *via* the chorda tympani geniculate ganglion, great superficial petrosal nerve and sphenopalatine ganglion to the maxillary division and to the brain Some additional fibers he believed entered *via* the lesser superficial petrosal nerve otic ganglion and third division The latter course was subsequently suggested by Ziehl (1889) on the basis of one case of isolated paralysis of the third division of the trigeminal

Eulenberg (1871) failing to find loss of taste after experimental section of the seventh and fifth nerves suggested that the fibers for the anterior two thirds *all* pass *via* the glossopharyngeal by a most circuitous route

Schiff s experimental observations were duplicated by Erb (1874) in clinical material Erb failed however to acknowledge the earlier studies which evoked a polemic in which Schiff stated that Erb had merely established for one animal (man) what he had himself already proved for other animals and that Erb would not have had the patience to carry out the tedious experiments which had been required to prove the matter

Lussana also came in for a share of criticism Taken to task by Vizioli (1869) for failing to give consideration to the work of Bernard he suggested that his critic apparently had not read an

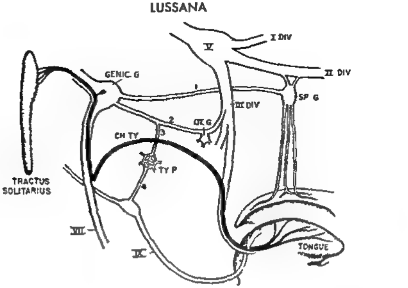

Fig 25 Schematic drawing showing course of gustatory fibers from the anterior two thirds of the tongue according to Lussana 1 Greater superficial petrosal nerve 2 Lesser superficial petrosal nerve 3 Anastomotic branch with the tympanic plexus 4 Tympanic branch of the glossopharyngeal

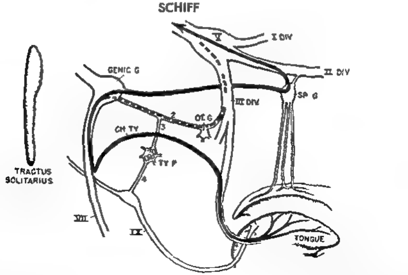

Fig 26 Schematic drawing showing course of gustatory fibers from the anterior two thirds of the tongue according to Schiff 1 Greater superficial petrosal nerve 2 Lesser superficial petrosal nerve 3 Anastomotic branch with the tympanic plexus 4 Tympanic branch of the glossopharyngeal

ZIEHL

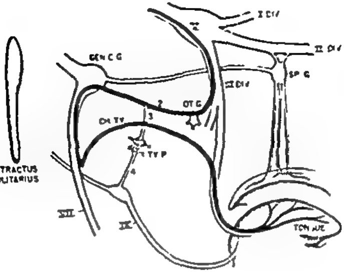

Fig 27 Schematic drawing showing course of gustatory fibers from the anterior two thirds of the tongue according to Ziehl 1 Greater superficial petrosal nerve 2 Lesser superficial petrosal nerve 3 Anastomotic branch with the tympanic plexus 4 Tympanic branch of the glosso pharyngeal

EULENBERG

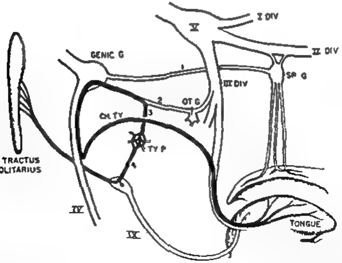

Fig 28 Schematic drawing showing course of gustatory fibers from the anterior two thirds of the tongue according to Eulenberg 1 Greater superficial petrosal nerve 2 Lesser superficial petrosal nerve 3 Anastomotic branch with the tympanic plexus 4 Tympanic branch of the glosso pharyngeal

earlier publication in which Bernard s work was discussed Far from having forgotten Bernard s work, said Lussana he was compelled to oppose that writer s views even though he was the *greatest physiologist of our epoch* Vulpian (1869) also rejected Lussana s views concerning the chorda tympani stating that it supplied the submaxillary gland furnished no fibers to the tongue and consequently could not be in any way considered as a gustatory nerve

To conclude the debate Lussana challenged Schiff to cut the maxillary division saying If taste is abolished after this operation I shall never cease to repeat Schiff s conclusions Interest in the taste fibers has thus from the beginning evoked controversy The question of their course has been and still continues to be an unsettled problem

Gowers tenaciously held to the view that taste enters the brain *via* the trigeminal basing his conclusions primarily on a case first seen in July 1880 reported in the *Journal of Physiology, A loss of taste from disease of the fifth nerve,* and subsequently referred to in 1885 and 1897 This patient was followed by Gowers for sixteen years He refers also to several similar trigeminal cases in each of which taste was lost

Gowers s method of testing may account to some extent for his findings To test taste on the front of the tongue he wrote touch the edge near the tip of the tongue on one side where taste is most developed The same is done on the back of the tongue For this purpose small bits of blotting paper dipped in quinine citric acid and sugar solutions were used It appears obvious that these tests applied only to a very limited area of the anterior part of the tongue In reporting the case referred to above Gowers wrote

> The interest of the case lies however not in its hypothetical pathology but in the circumstance that there was evidence of complete interruption of conduction along the sensory root of the nerve and that with this there was an entire loss of taste on the right side not only in the front of the tongue but also in the region in which taste is believed to be always subserved by the glossopharyngeal

And again

> But I believe that it will be found that taste impressions reach the brain solely by the roots of the fifth nerve and that the doctrine that the roots of the glossopharyngeal nerve have anything to do with taste is a curious physiological myth due to too wide an induction from certain anatomical facts and from dubious experiments on animals

From the point of view solely of the gross anatomical course of the taste fibers in man Gowers was quite justified in stating

> It is possible that nerve fibers for taste on the back of the tongue may be distributed with the ninth nerve reaching there from the otic ganglion of the trigeminus by the small petrosal nerve and the tympanic plexus This course I confess seems strangely circuitous but is scarcely more circuitous than that which is certainly taken by taste fibers of the front of the tongue

From the standpoint of gross human anatomy the lingual and trigeminal nerves were the obvious direct route from the anterior part of the tongue Gowers as late as 1897, was unalterably convinced that all gustatory fibers reached the brain stem *via* the trigeminal

> The path of taste from all parts in which this sense exists reaches the brain by the root of the fifth nerve

Having in mind the strangely devious course suggested by Schiff and Eulenberg Gowers concluded that

> Doubtless there is some developmental course for these wanderings and when the secret is discovered it will probably reveal also much regarding the evolution of taste and its relation to the other functions of the fifth nerve

Neither the fibers making up the tractus solitarius nor the geniculate ganglion and the circuitous course of the chorda tympani so clearly understandable from a comparative anatomical standpoint were given due consideration The fibers from the chorda tympani the palatine great superficial petrosal geniculate ganglion nervus intermedius and glossopharyngeal all join the tractus solitarius on entering the brain stem The course of the chorda tympani is not the same in man and the lower forms In fishes for example it follows a direct path from its origin

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series of eight cases with paralysis of the facial nerve from various causes there was complete loss of taste on the anterior two thirds of the tongue on the affected side One patient had sustained an injury of the seventh nerve in the course of an operation on the vestibular nerve for Meniere s disease five cases were associated with mastoid disease one patient had Bell s palsy, and one had sustained a fracture of the skull Preoperative observations on both sides of the tongue were made in two of the trigeminal series and in one of the glossopharyngeal As a result of their observations Lewis and Dandy concluded that taste is not transmitted by the trigeminal but by the facial for the anterior two thirds of the tongue, and by the glossopharyngeal for the posterior third The observations of Carmichael and Woollard were less clear-cut Of seventeen patients in whom the trigeminal had been rendered anaesthetic by alcohol injection, ten showed loss of taste on the anterior part of the tongue while in seven it was retained These investigators concluded that the loss of taste in so many of these fifth nerve cases is very puzzling and we feel that no satisfactory explanation has yet been obtained

Such diametrically opposed opinions coming from responsible observers suggest that there must be some basis for both views and that more detailed physiological and clinical studies are required to resolve the conflicts

Both Harris s conclusions and those of Carmichael and Woollard as noted were made on cases in which alcohol had been injected into the gasserian ganglion or its branches That alcohol under these circumstances might cause injury to the geniculate ganglion by spread through the hiatus Fallopii had previously been suggested by Dixon and Harris himself subsequently demonstrated the widespread distribution of injected material He found that injection of 1 cc of methylene blue solution almost invariably stained the whole of the ganglion deep blue and not the ganglion only but also sometimes the wall of the cavernous sinus the anterior surface of the pons and even the opposite cavernous sinus to a less extent Similar observations were made by Dandy (1929) and by Carmichael and Woollard The latter investigators found that material injected into the gasserian ganglion spread through the hiatus Fallopii to reach

in the geniculate ganglion to the tongue The circuitous course in mammals which disturbed Gowers arises from the intimate relation of the nerve to the quadrate bone which on being displaced by the mammalian temporo mandibular joint was drawn up into the middle ear carrying the chorda tympani with it There was no biological reason however for the chorda tympani geniculate ganglion or the nervus intermedius to for sake their historical gustatory function Furthermore never throughout the vertebrate series was gustatory function served by the trigeminal and its central connections within the brain stem

The views of Magendie Bernard and Gowers also held by Krause (1896) were soon challenged Dixon (1897) in his embryological studies pointed out that the great superficial *petrosal nerve and chorda tympani arose from the geniculate* ganglion in its early stages and were not connected with the trigeminal This origin was confirmed by the studies of Amabilino and Yagita cited previously showing that four fifths of the cells of the geniculate ganglion degenerate following section of the chorda tympani and 8 per cent after section of the great superficial petrosal nerve

Cushing (1903) reported retention of taste following seventeen of eighteen gasserian ganglion extirpations The experience of Davies was similar Harris (1926) on the other hand following his extensive experience with alcohol injections concluded I had found loss of taste on one side so constantly with few exceptions that I considered the point proved to my satisfaction while Frazier made the unequivocal statement that the trigeminal nerve supplies sense of taste to the anterior two-thirds of the tongue may be accepted without question'

Lewis and Dandy (1930) made a comprehensive study of taste following isolated total section of the trigeminal root at the pons in eight cases and intracranial section of the glossopharyngeal nerve for glossopharyngeal neuralgia in three cases Since these sections were done in the posterior fossa injury to the great superficial and lesser superficial petrosal nerves was avoided No disturbance of taste on the anterior two thirds of the tongue was found in either group On the other hand in all of a

eral neuron by which the impulse is conveyed No fibers from the trigeminal nerve however, have been found to join the gustatory tract

The tongue in its earliest development is represented by an immobile fold of mucous membrane devoid of musculature, in the region of the basi hyoid In the later course of development, the tongue musculature grows forward into the mucous fold from the post branchial region carrying with it the hypoglossal nerve which secondarily has been drawn into the skull to become a cerebral nerve

The mucous fold into which the musculature grows is made up of a posterior portion, derived from the first post hyoid arch, supplied by the glossopharyngeal nerve and an anterior portion belonging to the hyoid arch, innervated by the facial The somatic ectoderm supplied by the trigeminal becomes invaginated into the oral cavity so that *somatic* sensation to the oral cavity and the anterior part of the tongue is attributable to the trigeminal

All taste buds on the posterior third of the tongue are served by the glossopharyngeal while those on the anterior two-thirds are supplied by the pretrematic internal mandibular—the chorda tympani The roof of the mouth is supplied by the great superficial petrosal nerve through the palatine

Brief reference to studies already described in the chapter on Embryology and Anatomy is pertinent here Herrick (1903) showed that the catfish whose body is supplied with taste buds turns towards food placed beside the flank while those fish having no taste buds on the surface of the body either do not respond to food so placed or swim away Experiments done by Parker (1908) are also of fundamental importance in this connection In the hornpout taste buds are present not only in the mouth but over the entire external surface Those over the head are served by the rostrad branches of the facial and those over the body by the recurrent branch of the facial Bait presented to the flank as well as to the head was immediately snapped at while the response to sour saline and alkaline was to turn away from these chemical substances which apparently acted as nociceptive stimuli If the recurrent facial nerve were cut and bait placed beside the flank of the fish there was no response

the geniculate ganglion as well as into the posterior fossa over the cerebellar hemisphere In view of these observations it would seem that, even though no appreciable damage to the geniculate ganglion and the facial nerve were apparent patients in whom the gasserian ganglion or its divisions had been injected would not permit as precise and accurate an interpretation as those in whom the dorsal root had been sectioned with no possible associated injury to these other structures Frazier s cases fall into this latter category yet even in these there was loss of taste on the anterior two thirds of the tongue

Harris described his method of testing as follows

> The tongue is kept protruded and gently wiped while various tests are applied to the side of the tongue in solution such as syrup saline and quinine solutions The majority of individuals are unable to indicate by pointing to printed labels which of the tests is being used though evidently some gustatory sensation is perceived and it is not until they are permitted to withdraw the tongue into the mouth and move it about that the full sense of taste is developed Thus in all my tests of the sense of taste if the patient indicates by nodding the head that taste is perceived on the tongue I accept that as a positive result even though the quality of the taste may be uncertain until the tongue is returned within the mouth

It is not stated whether recognition of all three test solutions or only one was required as a criterion of taste perception Carmichael and Woollard applied their test material to the protruded tongue Failure of recognition in thirty seconds was taken to indicate loss of taste The substances used are not specified

As has been previously stated from a comparative anatomical standpoint the cerebral visceral nerves—facial glossopharyngeal and vagus in that order—are responsible for conveying taste impulses to the gustatory tractus solitarius In both the aquatic and terrestrial forms these three nerves have in addition a few fibers concerned with somatic sensation which on entering the brain stem join the descending trigeminal tract the pathway for somatic sensation from the head region irrespective of the periph

The function of these latter (intergemmal) fibers has not been definitely established Studying the innervation of palatal taste buds in *Amblystoma*, Herrick (1925) found that the palatal taste buds were encircled by dense skeins of nerve fibers which he termed circumgemmal fibers These he thought might be collaterals from the gustatory fibers or, possibly, independent ancillary fibers capable of reinforcing the gustatory impulse Unfortunately it was not possible to determine their origin

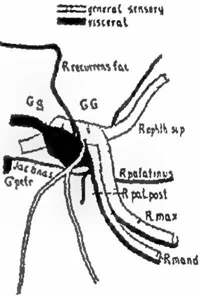

Fig 80 Diagram showing the trigeminal facial complex in the cod (Modified from C Judson Herrick) Lateralis and motor components omitted The anastomosis between the petrosal ganglion and the palatine rami is to be especially noted as such an anastomosis occurs somewhat similarly in man between Jacobson's or the tympanic nerve and the great superficial petrosal G G Gasserian ganglion G g geniculate ganglion G petr ganglion petrosum Jac anas Jacobson's anastomosis the pharyngeal or palatine ramus of the IX R mand ramus mandibularis V R max ramus maxilaris V R ophthl sup ramus ophthalmicus superficialis V R palatinus ramus palatinus VII R pal post ramus palatinus posterior VII R recurrens fac ramus recurrens VIII From original of figure 3 Ralph F Sheldon *Anatomical Record* 1909 Courtesy Wistar Institute Philadelphia

Taste buds on the tongue are found in the fungiform papillae * on the dorsal surface of the anterior two thirds of the tongue

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* It was interesting to find the following in Charles Bell's first anatomical communication *An Idea of a New Anatomy of the Brain* privately printed in London *1811* but reproduced in America in the same year a copy having been sent to Dr Nathaniel Potter then editor of *The Baltimore Medical and Philosophical Lyceum*

CONCERNING TASTE

There are four kinds of papillae on the tongue but with two of these only we have to do at present Of these the papillae (more numerous and smaller) resemble the extremities of the nerves in the common skin and are the organs of touch in the tongue When I take a sharp steel point and touch one of these papillae I feel the sharpness The sense of touch informs me of the shape of the instrument When I touch a papilla of taste I have no sensation similar to the former I do not know that a point touches the tongue but I am sensitive of a metallic taste

such as occurred when that nerve was intact Yet the presence of sour saline and alkaline again caused the fish to swim away Even after the lateral line was cut, in addition to the recurrent facial leaving only spinal nerves, the response to the chemical solutions was unaltered Since there remained only spinal nerve endings, these must be regarded as able to respond to chemical stimuli which are generally used in our clinical tests This was recognized by Parker who concluded the sense of taste is complex and involves not only the seventh nerve but also the free nerve endings of the spinal nerves

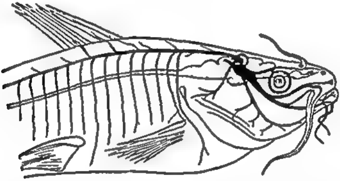
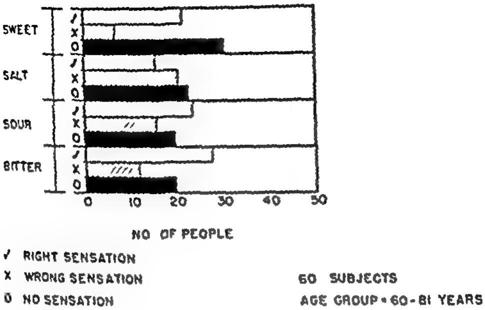


Fig [illegible] The cutaneous gustatory branches arising from the geniculate ganglion of the facial nerve of the catfish *(Ameiurus melas)* projected upon the right side of the body Spinal cord and brain stippled The geniculate ganglion its roots and cutaneous branches are drawn in black the branches of this nerve distributed to the mucous lining of the mouth cavity are omitted Taste buds are found in all parts of the outer skin to which these branches are distributed The recurrent branch is enormously enlarged in the siluroids C J Herrick *Introduction to Neurology* 1931 Courtesy W B Saunders Philadelphia

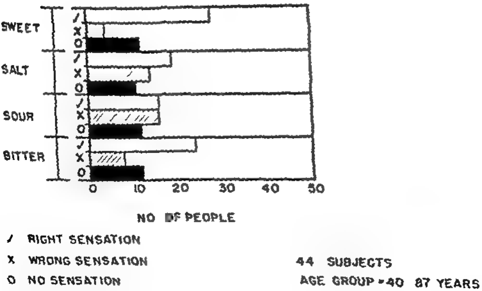
Kappers Huber and Crosby (1936) pointed out that in feeding experiments the positive reaction towards food is diminished when tactile fibers are severed in a given area having normal taste buds and that the correlation of these two types of sensation clearly plays an important part in determining the animal s ability to recognize and to locate the proffered nourishment

Gustatory nerve fibers end within the taste buds in a rich network of varicose fibers (*intragemmal* fibers) while other terminals of the same nerve finer and more delicate end in the epithelium between the taste buds (*intergemmal* fibers)

TEST 2



TEST 3



In our experience the sense of taste was present so frequently after trigeminal dorsal root section that we had regarded its retention as established However on finding in the literature such divergent opinions a further study and review of the problem was initiated

on the side walls of the circumvallate papillae on the posterior third and especially on the foliate papillae along the posterolateral margin of the tongue The circumvallate papillae are arranged in an open V at the junction of the anterior and posterior third These number only nine to eleven and are phylogenetically more recent than the foliate and fungiform papillae The last named number about 150 to 200 on the human tongue The total number of taste buds in man according to Huber is about 9 000 It is generally accepted that gustatory sense is greater on the posterior part of the tongue palate and fauces than on the anterior part yet it is the anterior part that is supplied by the chorda tympani

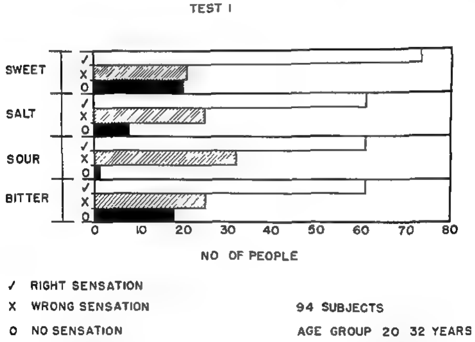


CHART 1 Results of testing gustatory sense in 94 young 60 elderly normal subjects and in 44 patients who had had trigeminal dorsal root section

While taste buds in the fungiform papillae are found on the tongue of the infant according to Stahr (1902) only an occasional such bud is seen in the adult This being the case the question naturally arises as to how the gustatory impulse is received on the anterior part of the tongue

(b) In twelve 27.2 per cent no taste was appreciated

IV (a) In eight patients 18.2 per cent when a bitter solution was applied a sense of taste was appreciated but the patient was unable to identify the substance

(b) In twelve 27.2 per cent no taste was appreciated

TABLE I

ANALYSIS OF GUSTATORY TEST

Taste Testing Substance	*Percentage Identifying Correctly* Young group (94 subjects av. age 22)	Group over 60 (60 subjects av. age 67.1)	Patients with dorsal root section (44 subjects av. age 66)
Sucrose 4%	7?.5	36.8	63.6
Negative Ion			
Sodium Chloride 1%	65.0	26.7	43.2
Citric acid 1%	65.0	40.0	36.4
Quinine sulphate 1%	65.0	46.6	54.5
All correct	33.0	6	11.4
All wrong	0	13.3	13.3

TASTE IN ELDERLY GROUP

	Age in Years Unoperated	Trigeminal Dorsal Root Section
All Correct	65.50	64.8
3	69.62	65.18
2	69.86	69.83
1	68.35	64.2
None Correct	70.31	71.0

This study was done on first year medical students in cooperation with the Department of Physiology Dr Walcott and Dr DiSalvo and the Neurological Institute residents Miss Darling Thomas very kindly prepared the charts The authors gratefully acknowledge the splendid assistance of these associates

Only one patient of the forty four failed to identify *any* of the four substances correctly

A point of great significance perhaps accounting for some of the discrepancies reported is that the integrity of both gustatory and tactile fibers may be essential for some substances to invoke the usual gustatory response—tactile sensation acting in an ancillary manner being perhaps of greater importance in some individuals than in others and for certain substances than for others Certainly after dorsal root section the tactile sense on the tongue

It was decided to test taste on the anterior two thirds of the tongue in a group of normal young persons a group of normal subjects over sixty and a group in whom trigeminal dorsal root section had been performed The usual taste substances were used sucrose 4 0 per cent sodium chloride 1 0 per cent citric acid 1 0 per cent quinine sulphate 0 05 per cent In making the test the tongue remained protruded and the individual was instructed to move his hand up and down on his thigh as soon as he recognized the test substance only then was he permitted to withdraw the tongue into the mouth In addition the four words sweet salt sour and bitter were printed on a card with one space blank The individual was asked to identify each substance by pointing to the card answers being accepted as correct if sucrose was identified as sweet sodium chloride as salt citric acid as sour quinine sulphate as bitter

The performance of the young group is rather surprising as is seen in the accompanying chart Only one third correctly identified all four substances approximately one third failed to identify salt sour or bitter whereas about one fifth failed to identify sweet

Though the age of the patients making up the operative group is almost exactly that of the older normal group the performance of the former in response to the various test substances was superior

Of forty four patients having had trigeminal dorsal root section only three or 6 8 per cent had lost taste on the anterior two thirds of the tongue In analyzing the results of our study further it was found that

I (a) In four patients 9 1 per cent when a sweet solution was applied to the anterior two thirds of the tongue a sense of taste was appreciated but the patient was unable to identify the substance

(b) In twelve 27 2 per cent no taste was appreciated

II (a) In fourteen patients 31 8 per cent when salt solution was applied a sense of taste was appreciated but the patient was unable to identify the substance

(b) In eleven 2 per cent no taste was appreciated

III (a) In sixteen patients 36 4 per cent when a sour solution was applied a sense of taste was appreciated but the patient was unable to identify the substance

CHAPTER IV

TRIGEMINAL NEURALGIA—CLINICAL FEATURES AND DIFFERENTIAL DIAGNOSIS

To be able to distinguish and to cure with some degree of certainty a disease that during the time it lasts is extremely excruciating is an addition however small to the utility of our profession — JOHN FOTHERGILL

Synonyms Trigeminal neuralgia has had a host of names It will be recalled that Andre designated it *tic douloureux*, Fothergill called it simply a *painful affection of the face* It became known shortly after Fothergill s report as *dolor faciei Fothergillii* and then *faciei morbus nervorum Crucians*, and still later as *trisma dolorificans epileptiform neuralgia, idiopathic neuralgia, hemicrania idiopathica, la grande neuralgie, trifacial neuralgia, idiopathic trigeminal neuralgia, major trigeminal neuralgia*, and finally simply as *trigeminal neuralgia*

Although the term tic douloureux has had considerable vogue and still appears in the literature it is not an accurate designation of the affection In adopting it Andre harked back to the ancients emphasizing the secondary convulsive and spas modic components which may be entirely absent and in any event never precede the primary feature of pain Actually the name could be applied with equal propriety to any other part of the body since it has no reference to the affected nerve

Definition Apparently some confusion has existed as to exactly what constitutes trigeminal neuralgia Dandy (1945) who con sidered trigeminal neuralgia as distinct from tic douloureux said of the former that it never displays the paroxysms so charac teristic of tic douloureux The pain is of a steady type varying in severity and lasting many hours or days without remission and even then the freedom from pain is usually incomplete

supplied by the trigeminal is lost, leaving only the few tactile fibers said to be derived from the chorda tympani

The stimulus in three of the test solutions employed is the negative ion which induces a nocireceptive response repelling rather than attracting To test gustatory sense rather than chemical stimulation substances are needed which do not contain a negative ion which attract rather than repel and which do not invoke olfactory sense Studies to this end are being undertaken

To summarize briefly our more recent observations after dorsal root section confirm the view that taste is not carried by the trigeminal nerve Experimental work and comparative anatomical studies suggest the participation in gustatory sensation of a chemical factor which may evoke a response in nerves other than the gustatory nerves and of tactile sense which may act to reinforce the gustatory response

It is obvious that a definitely standardized procedure should be developed with test substances which are not nocireceptive

day and that the lower jaw is commonly affected whereas pain in the temple brings the diagnosis into question

The following points in the diagnosis are to be stressed The pain must be paroxysmal with intervals of relief The attacks strike like a flash of lightning out of a clear sky and disappear as suddenly as they come In long standing cases an attack may last from thirty minutes to an hour though such duration is extremely rare The pain seldom occurs at night Not infrequently the patient may hesitate to acknowledge that he is free from pain between attacks but close questioning will bring out the fact that actually there is no pain in these intervals—only the constant fear that it will return This fear is always present *In a few cases a constant dull ache may persist between attacks*

Pain must be confined to the area of the trigeminal nerve in one or more of its divisions Its occurrence outside this area raises doubt as to the diagnosis and calls for further investigation and observation Occasionally there may be limited radiation in an adjacent field but with the pain predominant in the trigeminal distribution Such cases however should be viewed with skepticism

Fortunately bilateral trigeminal neuralgia generally affects but one side at a time Only in rare instances in our experience does the pain shift from one side to the other and even then it is constantly more severe on one side than on the other

While trigger areas about the lower lip upper lip alae nasi eyebrow or scalp are not always found their presence is one of the most valuable signs in clinching the diagnosis Patrick (1914) called attention to the diagnostic value of these areas which he designated dolorgenetic zones defining them as *areas in which a slight irritation starts the pain* Sometimes he wrote these zones are peculiarly restricted a spot no larger than a finger nail In the beginning the pain may be confined to the point from which it started to what one might call the *trigger area*

Algegenic trigger areas are usually at the terminal distribution of one of the trigeminal divisions and not along the border of an adjacent area The pain may be induced by the lightest contact Not infrequently the patient will cover the head and face to avoid a sudden draft of air or other precipitating factor

As to the responsible factor he wrote Usually an underlying tumor or infective process has impinged upon the peripheral branch of the gasserian ganglion This concept is of course at variance with the generally accepted definition of trigeminal neuralgia Pain in trigeminal neuralgia is paroxysmal and inconstant it never lasts for days and is never unremitting

In trigeminal neuralgia there is no objective evidence of disturbed function of the trigeminal nerve either motor or sensory as determined by the routine clinical examination The presence of sensory changes within the trigeminal distribution or weakness of the manducatory muscles at once raises doubt as to the diagnosis as do neural deficits in adjacent structures beneath the tentorium such as the acoustic nerve or other nerves and structures in the subtemporal region The possibility of a neighboring *organic lesion should always be considered and a complete neuro*logical examination is essential

The diagnosis of trigeminal neuralgia rests exclusively on the history and the character of the pain Not infrequently the patient will bring with him a member of the family to represent him and explain the nature of the attacks or he may elect to write his replies to the examiner's questions obviously fearful lest talking induce a paroxysm In spite of this latter possibility we prefer to have the patient tell his own story and in his own words describe the character of the pain His manner and behavior as he does so are a valuable aid in the diagnosis If indeed an attack is precipitated the diagnosis is clear From the point of view of the examining physician this is always desirable since the neurological examination is negative Nothing could be more unfortunate than to do a dorsal root section on a mistaken premise

The clinical description given by John Locke (1677) of the suffering of his Lady Ambassadress and the accounts of Andre (1756) Fothergill (1773) and Pujol (1787) still hold true The intervening centuries have added little to the accurate and minute portrayal with perhaps one or two exceptions of the character of the pain of trigeminal neuralgia presented by these distinguished physicians (see pp 8 17 24 27) Accumulated experience has shown that pain does not occur as often in the night as in the

Divisions Affected The ophthalmic division fortunately is far less often involved than the maxillary and mandibular It is generally conceded that it is affected in only 2 to 5 per cent of the patients In this series its incidence is 3 5 per cent This sparing of the first division may in some way be related to its origin since as has already been stated it represents a separate and distinct nerve which only secondarily has become associated with the maxillo mandibular Greater awareness of this dual origin would be indicated were we to designate the nerve as *bigeminal* rather than *trigeminal* in recognition of the circumstance that it is formed by the union of the two separate ganglia—the ophthalmic and the maxillo mandibular

Only if the pain is over the eye in the eye or over the forehead can one be sure the ophthalmic is the offending branch since this is the ophthalmic distribution Pain actually arising in the second or third division and following the auriculo temporal or zygomatic temporal branches of these divisions may extend to the temple suggesting an ophthalmic origin While such radiation is unusual its possibility must be borne in mind before it is concluded definitely that the ophthalmic is involved The trigger area for pain of ophthalmic origin is over the eyebrow, forehead and scalp Touching the eyebrow or brushing the hair will evoke a paroxysm If the ophthalmic alone is involved peripheral avulsion of the supraorbital and frontal nerves will give relief for several years establishing the diagnosis beyond doubt whereas if the seat of the pain is in the second or third division this will became obvious The ophthalmic division fibers are severed only when no alternate procedure is available

The second and third divisions are involved with about equal frequency Pain originating in the second division is referred to the upper lip ala nasi and cheek and less often to the gum and palate The slightest contact about the nose or upper lip induces an attack Touching the teeth or palate seldom causes pain Third division pain is referred to the lower lip and usually this is the trigger area The teeth and gum are often involved and the pain is deep seated The tongue is seldom painful

Secondary Radiation Pain may remain in one division for years without spreading and then be referred secondarily to

As suggested above the manner in which the patient describes the pain is significant Often he will hold the face immobile as he talks barely moving the lips or jaws and will point to the area of involvement but never venture to touch it His appearance and attitude are suggestive One side of the face may be

Fig 31 Patient having paroxysmal attack of trigeminal neuralgia

obviously unwashed showing an accumulation of desquamated skin If the mandibular division is involved the tongue may be heavily coated on the side of involvement and the teeth will not have been cleaned One patient most careful about her appearance had not been able to brush her hair or wash it for two years without frightful pain the scalp showing a thick deposit of desquamated epithelium

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Secondary Radiation Pain may remain in one division for years without spreading and then be referred secondarily to

another It has frequently been observed that alcohol injection in the division primarily involved relieves not only the pain in that division but the referred pain as well Radiation into an adjacent division is in many instances a secondary overflow phenomenon In these cases the paroxysms invariably occur in the division primarily involved and only now and then spread into another division The trigger area also is limited to the primary division Thus if the pain is consistently in the mandibular distribution and only occasionally in the maxillary with the trigger area in the mandibular the pain is classified as primary mandibular trigeminal neuralgia with secondary maxillary neuralgia We have only rarely seen secondary radiation skip a division that is from mandibular to ophthalmic or *vice versa* On the other hand pain in the maxillary not infrequently radiates secondarily to the ophthalmic so that true primary ophthalmic pain actually may be less common than the figures generally given would indicate By distinguishing primary and secondary forms one is able to follow a more conservative course preserving sensation and limiting the neural deficit which is the primary aim of differential section Harris (1940) apparently was unaware of differential section but recommended resection of the sensory root so as to spare the outer fibers belonging to the third division This sparing of the third division fibers may be of great value to the patient as eating on that side will be less interfered with

Remission The patient may be free from pain for weeks or months or even longer only to have it recur again Usually the intervals between attacks become shorter and the pain more severe with each recurrence a circumstance which has made it difficult to evaluate some of the treatments which have been thought to be beneficial We have been unable to relate a remission to any climatic change or any physical or emotional stress or strain The remissions are as baffling as the disease itself

Aetiology of Trigeminal Neuralgia The wisdom of Samuel Fothergill s (1804) comment concerning the aetiology of trigeminal neuralgia is as appropriate some hundred and fifty years later as it was when first written I do not even hazard a conjecture but wait till greater experience and information shall

throw some light on a subject which opinion cannot explain nor hypothesis prove. In spite of the numerous theories advanced, we still find ourselves confronted with opinions which cannot explain and hypotheses that are not proved.

With all deference to the opinions of the distinguished men who have advanced theories concerning the aetiology of trigeminal neuralgia, so far as we are aware, no pathological lesion has been *established* as the causative factor. Morphological changes of one kind or another have been described as being present in the peripheral nerve endings, the nerve fibers, or the nerve trunks (perifilamentous adhesive neuritis). Narrowing of the foramen of exit has been held responsible, or pressure by the accompanying artery on the nerve as it emerges through the foramen. The ganglion cells have been implicated and the basket fibers surrounding them. Abnormalities of the dorsal root as it passes into the posterior fossa, local demyelinization with artificial synapse, dorsal root compression by tumors or by abnormal blood vessels, traction on the dorsal root associated with platybasia, deficient vascular supply due to atheromatous changes in the carotid and smaller blood vessels, paroxysmal ischemia, functional vascular disorders, and lesions in the thalamus are a few of the many suggested causes—none of them proven.

In the presence of a clinical entity as definite in its manifestations as trigeminal neuralgia, it is understandable that theories concerning its cause should be presented. These have multiplied with each new method of treatment, whether medical or surgical. Little is to be gained, however, by a critical discussion of the many ideas which have been propounded. While in some patients one or another of the suggested lesions may be found, not one of them has been encountered with sufficient constancy to be accepted as the aetiological factor, though some of them have been advanced with considerable certainty.

Kinnier Wilson (1941) considered the neuralgic paroxysm to be a sensory epileptiform discharge which does not possess a morphological pathology. Inasmuch as the centrifugal paths are in a normal state, conducting impulses, no morphological lesion of ganglion cells or conducting mechanism is likely. If lesions exist, they should be sought rather in some *efferent* sensory

inhibitory mechanism which a variety of reasons suggest it is needful to postulate. The terms used by Hughlings Jackson for epilepsy are equally applicable to trigeminal neuralgia in that trigeminal pain is an occasional sudden excessive rapid and local discharge which may endure but a few seconds or moments. If this functional concept be accepted the explanation must be essentially physiological.

The exciting stimulus may arise from the slightest afferent impulse from the trigeminal area (trigger mechanism) or an attack may occur without any such stimulus due presumably to a sudden central discharge. All evidence seems to point to a central rather than a peripheral origin. It seems improbable that a lesion so discrete affecting but one division and even part of a division as the mandibular without implication of the tongue would reside within the thalamus. A more likely location for so limited a focus would be somewhere between the entry zone and the thalamus probably within the brain stem.

List and Williams (1957) have presented an excellent review of both the morphological and physiological aspects of trigeminal neuralgia. The neurophysiological investigations of King and Meagher (1955) and King Meagher and Barnett (1956) may lead to a more adequate understanding of the mechanism of pain production than has heretofore been available. These workers in experiments on cats studied the effect on trigeminal potential of stimulation and section of the spinal trigeminal tract and of the injection of aluminum gel into the spinal trigeminal nucleus as well as into the main sensory nucleus. In animals rendered over sensitive by the injected material they found a 300 to 600 per cent increase in the recorded voltage of centrifugally conducted delayed activity in the peripheral divisions of the trigeminal which arose from the lower medulla and first cervical segment. A part of this delayed activity was set in motion at touch threshold and conducted peripherally along the trigeminal nerve.

With the limited evidence at hand it is entirely possible that theoretical neurophysiological assumptions may be as misleading as have been the numerous morphological theories advanced in the past. It would appear, however that a neurophysiological attack will yield a greater understanding of the aetiology of

trigeminal neuralgia than the morphological hypotheses thus far presented It could not yield less

Whatever aetiologic view prevails, it is doubtful if the surgical treatment already established will be materially altered Of greatest interest is the possible interrelation of the caudal descending trigeminal nucleus and the most cephalic extension of the cervical dorsal horn and substantia gelatinosa of Rolando, since a few patients apparently have been relieved by blocking of the great auricular or the great occipital nerve derived from the second cervical segment This region becomes all the more interesting since the cutaneous and pain fibers of the facial, glossopharyngeal and vagus on entering the brain stem join the descending trigeminal tract as has been indicated by comparative anatomical studies and by observations following tractotomy to terminate in the caudal descending trigeminal nucleus Trigeminal geniculate and glossopharyngeal neuralgia would thus seem to have a common denominator the pain being essentially identical in character severity and suddenness of onset, differing only in its distribution and resembling that attributable to no other nerve

Heredity in Trigeminal Neuralgia In considering the relation of heredity to trigeminal neuralgia one needs to tread warily The affliction is not a rare one and were it inherited either as a dominant or a recessive trait its familial occurrence would by now have been repeatedly observed instead of being as it is a clinical rarity Its occasional occurrence in succeeding generations is nevertheless of interest and suggests further study

Harris in 1936 stated that he had seen eleven families in which more than one member suffered from the disease nine in which a parent and child were affected and two in which the relationship was that of grandparent and grandchild Four years later (1940) he was able to state I have met with thirty cases of trigeminal neuralgia in which heredity of the disease played a part In six or 20 per cent the neuralgia was bilateral In a few there was also a history of multiple sclerosis in a near relative In his 1936 paper the age at onset is given for five families as follows

Father pain began at	60	daughter at	44
Mother	68		41
Mother	54 *		53
Mother	46	son	34
Father	60–70		50

* Subsequently developed bilateral pain

In addition Harris called attention in his earlier paper to a most unusual instance of familial occurrence of trigeminal neuralgia the disease appearing in nine members in three generations In his later communication presumably referring to the same family he stated that he had treated three members of a family for trigeminal tic in which there had been eleven sufferers from the disease in three generations 3 3 and 5 It would appear that the two additional cases developed between 1936 and 1940 If such be the case a continued study of this unique family would be most valuable It is of interest that in two cases in the third generation the disease was bilateral

Castner Vendrell and Barraquer Bordas (1949 50) cited six members of a family with trigeminal neuralgia in four generations and Allan (1938) three members in three generations

In all of these families anticipation was the rule the disease appearing at an earlier age in each succeeding generation

The incidence of familial occurrence of trigeminal neuralgia in Harris s statistics is 2 6 per cent while Lewy and Grant (1938) obtained a familial history in 6 per cent of their series On the other hand Horrax and Poppen (1935) report no familial cases among 468 patients No mention is made of an hereditary factor by Coleman Meredith and Troland (1948) in their series of 600 or by Peet and Schneider (1952) in their detailed analysis of 689 cases Nor have we found any evidence of inheritance

It might be as suggested by Allan that the hereditary factor would be recognized in considerably more than 1 per cent of cases if it were sought Harris however as mentioned above in spite of his special interest in the matter was able to report only thirty cases out of a total of 1 433 Thus from a statistical standpoint heredity on the basis of the data at hand cannot be considered more than an incidental finding

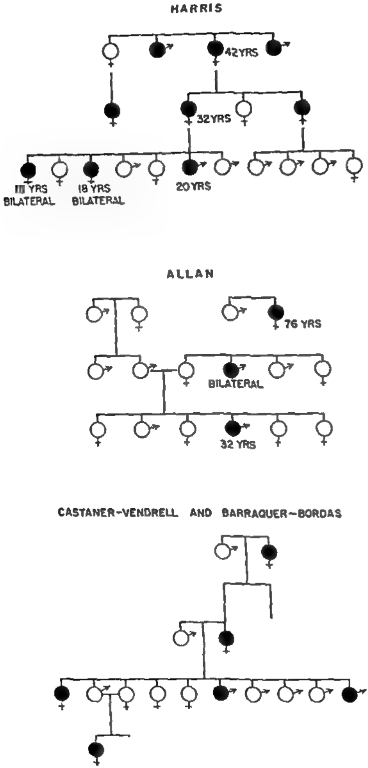

Fig. 32 Heredity in trigeminal neuralgia as indicated by Harris Allan and Castaner Vendrell and Barraquer Bordas

Atypical Facial Neuralgia—Prosopalgia

Every pain has its distinct and piquant significance if we will carefully search for it — John Hilton

In any neurosurgical clinic many patients apart from those suffering from trigeminal neuralgia are seen complaining of pain in the face Our efforts to treat this group have been most disappointing Some years ago when the senior author was asked at a neurosurgical meeting how he treated such patients his reply was I let them severely alone implying that the less done for them surgically the better The intervening years have brought forth little to alter the view then expressed

These patients may be divided into two main categories one with pain confined to the face and a second in which the pain involves the face *and* the head often radiating into the neck and shoulders

In the first group the pain may be limited to the central part of the face the maxillary area or the region of the eyeball and forehead suggesting neuralgia of the maxillary or ophthalmic division of the trigeminal more rarely, it is in the lower jaw and the mandibular region But while the area affected may correspond more or less exactly to the region of any one of the three trigeminal divisions the pain differs quite markedly from that of trigeminal neuralgia in mode of onset and radiation as well as the factors tending to aggravate it It is deep and nagging and is not referred to the periphery The patients are often at a loss to describe the nature of their suffering and not infrequently adopt terms suggested by the examining physician Dull aching pulling drawing pressing boring throbbing burning unbearable are among the adjectives used The attacks separated by varying intervals of relief gradually increase in intensity over an hour a day or several days sometimes reaching a point of great severity They subside usually gradually rarely abruptly

In the second group while the pain may have some of these same characteristics and in part the same distribution it extends beyond the trigeminal area over the forehead to the occiput and mastoid region onto the neck and in some instances to the shoulder Frequently associated are cranial autonomic phenomena

increased lacrimation engorgment of the nasal mucosa a nasal discharge and occasionally tenderness over the cranial vessels though not all of these signs may be present in any given patient Cases of this second group do not resemble trigeminal neuralgia sufficiently to call for the close scrutiny demanded for differentiation of the first group since it is obvious that the painful region is well beyond the trigeminal distribution

Actually the use of the term atypical facial neuralgia for this second group is entirely inappropriate, since the cases belong in an entirely separate category described by Vallery Radot Pasteur and Blamoutier (1925) as hemicephalic syndrome of vaso dilatation by Brickner and Riley (1935) as autonomic facio cephalalgia and by Horton MacLean and Craig (1939) as erythromelalgia and later because of their response to histamine, as histamine cephalalgia To be sure not all examples falling within this category represent identical clinical entities but they are closely related belonging to the large group so thoroughly studied by Wolff and his co workers (1948) who recognize them as primarily painful vascular disturbances and include them under the general designation painful cephalic vascular disorders

As this latter term implies the disturbance is primarily within the cephalic vascular tree rather than the trigeminal nerve Either the vessels themselves are involved in the form of arteritis of the superficial temporal and meningeal vessels or the carotid or the nerve fibers should be held responsible for vasodilatation as suggested by Cobb and Finesinger (1932) and Chorobski and Penfield (1932) The views of these latter groups of observers were later applied clinically by Gardner Stowell and Dutlinger (1947) when they severed the great superficial petrosal nerve for the relief of unilateral headache

From the point of view of differential diagnosis only the first of the two groups need be considered In these cases the pain may cease for weeks or months and then recur While the region involved is generally unchanged it may gradually increase in extent as the duration of the condition comes to be reckoned in years Seldom is there a shifting of the pain from one side to the other but in long standing cases it may become bilateral In this event it is symmetrical in distribution but the intensity is

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unequal being greater in the original site Worry fatigue and climatic conditions—either heat or cold—are frequent aggravating factors Light contact on the other hand seldom acts in this capacity as it so commonly does in trigeminal neuralgia Trigger areas are usually absent The patient may describe his symptoms at length without giving the slightest indication of suffering even to the trained observer Yet when the question is put as to whether the pain has been present continuously during the taking of the history the reply is almost invariably in the affirmative

If the patient is asked to locate the painful area instead of pointing to the region and carefully refraining from touching it—the typical response in trigeminal neuralgia—he will press firmly and vigorously to indicate the depth of the pain as if unconsciously trying to punish or destroy the region The gesture is one of resentment and in some instances is of psychological significance

Some attempt has been made to correlate trigeminal and atypical facial neuralgia with body build In our experience however neither group conforms to any particular type of physical or mental makeup whether it be the linear or the lateral growth type as described by Stockard (1923) Any relationship would appear to be wholly coincidental Undoubtedly the basic psychology of the individual and his mental reactions are associated with his structural and glandular build While it is thought that the individual of linear type is more self conscious and nervous he nevertheless tends to control and conceal his emotions while the reverse is true of the lateral type

The impact of continuing relentless pain upon the personality is inevitably damaging so that the atypical facial neuralgia patient when seen after years of constant suffering impresses one as worrisome nagging and complaining whereas the patient with true trigeminal neuralgia though suffering greatly is more likely to have become adjusted to his affliction and does not whine nor seek understanding and sympathy This apparent stoicism may be related to the *obvious* severe and excruciating pain which when it strikes does so with such evident violence as to elicit sympathy and understanding on the part of the observer In the atypical case there is no such visible attack the pain is as it were con

cealed compelling the patient to call attention to its severity The oft repeated story unsupported by outward manifestations of suffering eventually evokes only skepticism which in turn, has its effect on the personality making it difficult to evaluate either the personality or the pain

The neurosurgeon must be aware of the psychic aspects of facial pain and must search for other complaints which in summation would suggest the need for psychiatric investigation Patients have been referred to psychiatrists from time to time with varying results Engel (1951) who made an intensive psychoanalytic study of twenty cases of atypical facial neuralgia held that the complaint is an hysterical conversion symptom All his patients were proved to be psychologically ill and he was convinced that the pain was a symptom of that illness His conclusion was that the atypical facial neuralgias are identical with the facial pain commonly met with in psychoanalytic practice

That Engel was correct so far as a certain number of cases are concerned is unquestionable but to include all the atypical facial neuralgias in the category of hysterical pain as he suggested is too sweeping a generalization His conclusions were based not upon a series of typical cases but rather upon a selected group which cannot be regarded as classical examples of the disease All but one of his patients were females and the average age was thirty nine The case presented by Engel as representative of the group was that of a twenty seven year old woman with a history of pain in the right face eye head and cheek for sixteen years Another twenty seven year old woman had experienced pain in the head and face for twenty years and a third forty five years old for twenty seven years These cases are certainly not characteristic of atypical facial neuralgias as commonly seen by the neurosurgeon

But though we cannot accept in their entirety Engel s conclusions his careful analytical study has contributed to an understanding of the mechanisms involved in the unconscious need of these patients to suffer the reciprocal relationships and guilt displacements In the majority of his patients the simplest detailed history would have elicited a number of other complaints suggesting the need of psychiatric help rather than neurosurgical His insistence upon such a search is a point well made

To repeat in a number of instances the problem is one of conversion hysteria but we cannot agree to designate the entire group of atypical facial neuralgias as hysterical face pain

When the pain remains within the trigeminal area, but is still not characteristic of trigeminal neuralgia an alcohol in jection may be tried as a diagnostic measure This relatively simple procedure however may enhance the patient s distress the induced numbness becoming an added burden Caution in the use of the procedure is imperative

We agree fully with Glaser (1928) that no remedy applied directly to any branch or division of the trigeminal system is in the least helpful no operation dealing with the structures within the pain territory especially the teeth and sinuses will give the patient the slightest relief Not only do physical measures fail to afford relief but they frequently make matters worse Surgical procedures should therefore be undertaken only after careful deliberation—whether the operation be directed to the sinuses the teeth or above all to the trigeminal nerve The need for caution cannot be overemphasized

Among the simpler procedures which we have found to afford relief in an occasional case is the use of vasodilators such as betamethylcholine chloride inhalations of amyl nitrite and nicotinic acid on the assumption that the widespread painful area may be part of a vasoconstrictor reflex or due to pressor substances within the blood stream Cobra venom also a vaso dilator may be of help in true trigeminal neuralgia but seldom relieves the pain in the atypical case Trichlorethylene mild sedatives cocainization of the sphenopalatine ganglion and in stillation of cocaine into the eye have occasionally proved effective

The distress and suffering in this group demand continued effort and an unceasing search for measures which may conceivably help yet not add to the burden of the patient Drug addiction is a threat in these cases as it is not in trigeminal neuralgia In this latter condition the pain is beyond the control of opiates and resort to their use is therefore unusual Patients with atypical facial neuralgia on the other hand frequently seek the relief thus afforded

The term atypical facial neuralgia was introduced by Frazier

and used by Grant, and Glaser in a number of articles to describe a group of patients who have pain in the face which is not true trigeminal neuralgia The term has gained general currency and has been greatly expanded to include a host of unrelated clinical entities, many of which bear little or no resemblance to trigeminal neuralgia Glaser (1928 1938 1940), using this title has written extensively and made a particular study of these patients He has divided atypical neuralgia into four categories

I Primary atypical facial neuralgia

II Secondary atypical neuralgia due to various clinical entities

1 Sphenopalatine and vidian neuralgia

2 Postherpetic trigeminal neuralgia

3 Trigeminal ghosts

4 Trigeminal ghosts with lingual spasm

5 Syndrome due to abnormalities of the mandibular joint

6 Autonomic faciocephalalgia

7 Painful convulsive tic

8 Headache due to hypertonicity of muscles of the neck

9 Senile neuralgia

III Atypical facial neuralgia produced by systemic diseases

1 Allergy

2 Endocrine disturbance

3 Psychoneurosis

IV Atypical facial neuralgia due to lesions of the head chest and abdomen

1 Infections about the head

(a) Mastoiditis

(b) Thrombosis of the cavernous and longitudinal sinuses

(c) Deep seated facial abscesses

2 Tumors of the head and neck

3 Intracranial lesions
4 Dental sepsis
5 Deviations and spurs of the nasal septum
6 Ocular lesions
7 Lesions of the chest
8 Pathologic conditions in the abdomen and pelvis

It is apparent from this classification that atypical facial neuralgia as the term has come to be used has lost any resemblance it may have had to the clinical entity from which it originally derived its origin The list embraces heterogeneous groups some of which are due to actual neuritis as pain following *herpetic eruptions systemic disease various tumors of the* head and neck and pathological conditions of the chest abdomen and pelvis

When Magendie (1825) first described the cephalo rachidian fluid he said I have begun by giving a name to *my* liquid a name is a great deal even in anatomy A name *is* a great deal even in neurosurgery A name tends to catalogue and to create the idea that a definite clinical entity has been established it puts the subject at rest and therefore is likely to discourage instead of stimulating further investigation This has been the case with atypical facial neuralgia

What is required is sharper delineation and definition *Facial* neuralgia is used by many as synonymous with *trigeminal* neuralgia Atypical implies at least sufficient resemblance to warrant inclusion in the category from which it has deviated yet many characteristics are lacking which would justify such a classification Were the term limited as Frazier originally employed it it would perhaps be acceptable as now used it tends to lead away from a penetrating analysis of the various categories included There is need to hew more exact clinical entities out of this all inclusive block not only that they may be distinguished from trigeminal neuralgia but that they themselves may be more clearly delineated Steps in this direction have been made with the description of glossopharyngeal neuralgia tympanic flexus neuralgia geniculate neuralgia and sphenopalatine and vidian neuralgias all of

which have points in common with and in some instances closely resemble true trigeminal neuralgia and once constituted a part of the atypical group

In summary the term atypical facial neuralgia lends itself to the inclusion of a number of diverse clinical entities which by implication at least *resemble* trigeminal neuralgia but are not *typical* of that disease It is suggested that the term atypical *trigeminal* neuralgia and not atypical facial neuralgia be used to designate those cases in which the pain so closely resembles trigeminal neuralgia as to require close scrutiny to differentiate it from the true form and which are without objective evidence of neural dysfunction Others characterized by pain in the face but *not* in the head should be given a more general designation in which the word atypical is omitted Such an all inclusive term as prosopalgia (Greek *prosōpon,* face and *algia,* pain) should perhaps be revived It was employed over a hundred years ago in a thesis by Reverdit (1817) to indicate tic douloureux but never came into general usage Hunt suggested it be used to designate a deep form of pain in the face as an integral part of geniculate neuralgia which he believed was included in the so called atypical disorders of the face If restricted to its primary meaning *pain in the face* and *no more* it would be an adequate generic designation without specific implication or relation to any given nerve and yet suggest the need for further investigation

The group would thus be broken into three categories painful cephalic vascular disorders atypical trigeminal neuralgia and prosopalgia Such a division should contribute to our knowledge of the specific groups permit of their differentiation and clarify our understanding of the problems involved In each field there remains much to be done with constant awareness of the psychiatric aspects and the need for further investigation

Glossopharyngeal Neuralgia

Only relatively recently has glossopharyngeal neuralgia been recognized as a definite clinical entity Sicard and Robineau (1920) described three patients with unilateral paroxysmal pain in the fauces and pharynx brought on by swallowing chewing and even by speech They sectioned the glossopharyngeal the

pharyngeal branches of the vagus and the cervical sympathetic bringing about complete relief in one case for four years and in the others for three years Since the operation disturbed the function of three nerves the authors were unable to isolate the offending glossopharyngeal They termed the syndrome *algie velo pharyngee essentielle* and recommended section of the glosso pharyngeal and the pharyngeal branches of the vagus as well as the cervical sympathetic

Harris (1921) a year later described patients who had come under his care as having glossopharyngeal neuralgia His first patient seen in 1910 suffered excruciating pain in the right side of the throat which came on quite suddenly lasting a few seconds and reappearing on swallowing There were numerous attacks all starting in the throat never in the ear though touching the auricle or external auditory meatus induced the pain The right trigeminal mandibular division was injected with alcohol and though complete anaesthesia was induced the pain was not altered Harris s second patient eighty seven years old was seen in 1914 with severe pain in the left side of the throat and left ear made worse by eating or swallowing Since touching the ear brought on acute paroxysms the patient had refrained from even washing it! Alcohol injection in the mandibular division gave no relief

Following Harris s paper Siebert (1921) reported three cases of glossopharyngeal neuralgia with unilateral paroxysmal pain at the base of the tongue and pharynx Four cases from the Mayo Clinic were reported by Doyle in 1923 In one a diagnosis of atypical neuralgia was made and the trigeminal dorsal root was cut without relief Later by a modification of the procedure of Sicard and Robineau the pharyngeal nerve in the neck and the pharyngeal branches of the vagus were cut In a second case the mandibular division of the trigeminal and the auriculo temporal nerve were injected without relief The third patient left the Clinic before any operation was undertaken and the fourth was too poor a risk for surgery The following year Adson (1924) reported three additional cases in which peripheral glosso pharyngeal evulsion was done after which the pain recurred as it does after peripheral operations upon the trigeminal nerve

Adson advised dorsal root section for permanent relief Subsequent papers by Singleton (1926) Dandy (1927), Stookey (1928), and Bailey (1931) appeared Peet (1935) reported fourteen cases of glossopharyngeal neuralgia in five of which there was associated trigeminal neuralgia requiring trigeminal dorsal root section as well as glossopharyngeal root section In one of these bilateral glossopharyngeal neuralgia developed, necessitating bilateral glossopharyngeal section The patient was completely relieved of pain It is unfortunate that there was not a more adequate follow up in this case, since such extensive pain is rare in true neuralgia but common in malignant disease These reports were followed by still others and today the glossopharyngeal nerve, once described by Dana (1926) as having no tic or palsy or algia receiving only disregard and aloofness from surgeons and clinicians has become of great interest to both groups

The pain of glossopharyngeal neuralgia may at first be limited to the ear or to the throat or it may be present in both areas Pain deep in the ear paroxysmal and unbearable is a frequent feature In those patients seen by the senior author it seems if possible to be even more agonizing than the pain of trigeminal neuralgia incredible as this may appear During the attacks the patient may insert his finger in the ear as deeply and with as much force as possible as if trying to push through to the opposite side Between attacks merely touching the ear may induce pain and with its onset the urge to dig into the ear is almost irresistible Other patients complain only of pain in the throat induced by swallowing or even by talking Here also the pain is paroxysmal and excruciating When asked to locate it the patient points to the outside of the throat to the peritonsillar region

When the characteristic paroxysmal pain is present in both the ear and the throat the diagnosis of glossopharyngeal neuralgia is unquestionable and there is little likelihood of confusion with trigeminal neuralgia In some of the earlier cases reported before the recognition of glossopharyngeal neuralgia as a clinical entity the pain was originally limited to a single site Thus the first patients described by Sicard and Robineau as well as Harris s first two patients had pain only on swallowing Under such circum

stances even those with a considerable experience with trigeminal neuralgia failed to distinguish between the two conditions Harris for example, sought to alleviate the pain by injection of the third trigeminal division Doyle also injected the third division as well as the auriculotemporal nerve after sectioning the dorsal trigeminal root without however diminishing the attacks of pain Jefferson (1931) having failed to obtain relief by a differential trigeminal dorsal root section in which he cut the third and part of the second division fibers performed a total trigeminal dorsal root section again without relief Only after the second operation when pain appeared in both the ear *and* the throat was the diagnosis unmistakably established

Fig 38 Patient with glossopharyngeal neuralgia showing attitude assumed during attack

It thus appears that glossopharyngeal neuralgia need not involve all branches of the nerve simultaneously any more than trigeminal neuralgia need affect all divisions of that nerve Reichert (1933) and Erickson (1936) recognized that pain may be limited to the tympanic branch of the glossopharyngeal Such cases Reichert described as tympanic plexus neuralgia while Erickson preferred the more precise designation—paroxysmal neuralgia of the tympanic branch of the glossopharyngeal nerve

The differential diagnosis does not lie so much between glossopharyngeal neuralgia and trigeminal neuralgia though both may be simultaneously involved as between glossopharyngeal and

geniculate ganglion neuralgia In view of the complexity of the sensory system and the extensive overlap of the innervation about the ear the difficulty of accurately diagnosing aural pain unassociated with other complaints is not surprising

Fig 34 Patient with glossopharyngeal neuralgia indicating location of pain

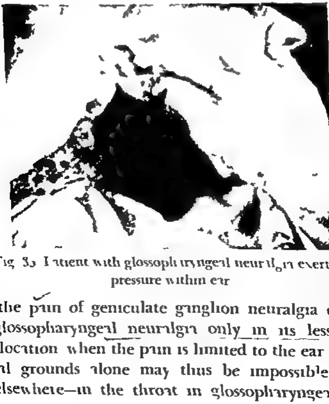

Fig 35 Patient with glossopharyngeal neuralgia exerting pressure within ear

Actually the pain of geniculate ganglion neuralgia differs from that of glossopharyngeal neuralgia only in its lesser severity not in its location when the pain is limited to the ear A diagnosis on clinical grounds alone may thus be impossible until pain appears elsewhere—in the throat in glossopharyngeal neuralgia

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The motor changes incident to the operation are inconsequential and extremely limited, indicating that section of the glossopharyngeal root can be done with little if any motor inconvenience to the patient The *mouvement de rideau*, described by Vernet (1917) as pathognomonic of injury to the ninth nerve and paralysis of the superior constrictor has not been observed The dorsal wall of the pharynx moves equally well on both sides without deviation Difficulty in swallowing liquids is not experienced, though solid foods such as dry toast may cause some trouble at first This however soon disappears and the patient is able to swallow as well as before operation It is thus evident since deviation of the pharyngeal wall is not produced and swallowing is not permanently impaired that the ninth nerve is not the principal motor nerve of the superior constrictor muscle of the pharynx That this nerve may contribute a small twig is possible in view of the temporary weakness of the muscle following glossopharyngeal section but certainly it is not responsible for the total innervation

The only evidence of permanent motor weakness following section of the glossopharyngeal root is a sagging of the palatal arch on the side of the operation, observed only when the palate is at rest This may be taken to suggest that the palatopharyngeus and palatoglossus muscles forming the posterior and anterior arch of the fauces are supplied by the ninth nerve The stylopharyngeus muscle supplied by the ninth nerve fuses and becomes continuous posteriorly with the palatopharyngeus muscle relaxation of the former may contribute in part directly to the relaxation of the latter

The association of glossopharyngeal neuralgia with carotid sinus sensitivity was first reported by Riley and his associates in 1942 Two of their patients with glossopharyngeal neuralgia exhibited also syncope general convulsions cardiac arrest and vasodilatation with fall in blood pressure These changes were attributed to the cardiovascular regulatory mechanism mediated through the carotid sinus by the afferent fibers which pass *via* the glossopharyngeal to establish central connections with cardiovascular centers while the efferent link reaches the heart by way of the vagus The role of the carotid sinus in syncope and con

or in the deeper structures of the face, the posterior nasal or palatal regions in geniculate neuralgia Reichert operating under local anaesthesia found that touching the facial nerve did not induce neuralgic pain but, when the glossopharyngeal was touched a typical paroxysm ensued enabling him to distinguish between the geniculate and the glossopharyngeal

Fortunately dorsal root section of the glossopharyngeal, at its entrance into the jugular foramen is readily accomplished and gives permanent relief leaving in its wake essentially no unfavorable after effects Visceral sensory changes have been found at the base of the tongue fauces soft palate and uvula and pharynx in the area generally attributed to the glossopharyngeal No definite somatic sensory loss has been detected however about the ear external auditory canal or behind the ear

Fig 36 Nasopharyngeal sensory field of the glossopharyngeal nerve shown in black Stookey 1928 (*Arch Neurol & Psychiat* Courtesy American Medical Association Chicago

relieved by dorsal root section of the glossopharyngeal and the rostral rootlets of the vagus No statement was made concerning the effect of pressure upon the carotid sinus

Harris as mentioned earlier noted the association of glosso pharyngeal neuralgia and convulsions but did not correlate the two nor record any cardiac abnormalities mediated by the glossopharyngeal nerve Following the report of Riley *et al*, Ray and Stewart (1948) described an instance of glossopharyngeal neuralgia with an increased carotid sinus reflex Here as in the case of Karnosh *et al*, section of the glossopharyngeal afforded relief of the neuralgia and abolished the episodes of cardiac arrest

Roulhac and Levy (1950) cited a patient in whom convulsions preceded by pain in the throat were induced by stimulation in the throat and abolished by cocainization of the region of the left tonsil Stimulation of the carotid sinus had no effect Section of the glossopharyngeal root abolished pain in the throat immedi ately and the patient was able to talk normally In addition two vagal rootlets were sectioned though stimulation of these did not reproduce pain in the throat but in the ear

In a case seen by Svien Hill and Daly (1957) and identified as partial glossopharyngeal neuralgia paroxysmal attacks of pain occurred in the ear precipitated by swallowing Some six years after the first attack the patient began to experience sudden loss of consciousness in association with the paroxysms of pain with pallor and slowing of the pulse Pressure on the carotid sinus did not give rise either to syncope or the characteristic pain Complete relief followed section of the glossopharyngeal and the rostral fourth of the vagus rootlets

Geniculate Ganglion Neuralgia

It is doubtful whether geniculate neuralgia would be confused with typical trigeminal neuralgia Some of the so-called atypical forms of trigeminal neuralgia however present symptoms which fit into the syndrome so clearly presented by Hunt in a number of papers (1907 1909 1915 1937)

Hunt was the first to produce evidence that in man the facial nerve as it makes its exit from the skull carries somatic sensory fibers destined for the external ear part of the auditory

vulsion had previously been described by Weiss and Baker (1933) and Sheehan Mulholland and Shafiroff (1941) had established the course of the afferent fibers through the glossopharyngeal nerve

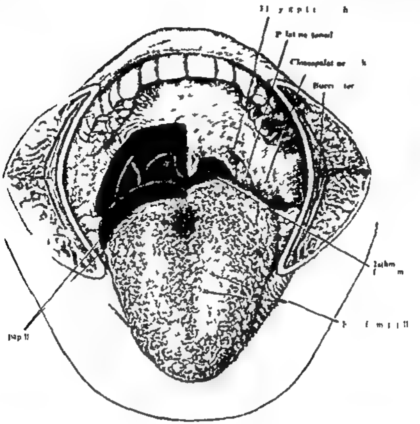

Fig 37 Labial and lingual sensory field of the glossopharyngeal nerve shown in black Stookey 1928 *Arch Neurol & Psychiat* Courtesy American Medical Association Chicago

Neither syncope nor convulsions are necessarily associated with carotid sinus irritability Karnosh Gardner and Stowell (1947) examined a physician complaining of paroxysmal pain in the tonsillar region precipitated by talking chewing and swallowing and accompanied by dizziness In the course of the examination the patient had two seizures with complete cardiac arrest for eight seconds confirmed by electrocardiographic tracings parallel ing the attack of pain The cessation of heart beats was ascribed to over stimulation of the motor nucleus of the vagus and not to the influence of the carotid sinus The patient was completely

In addition to the cutaneous herpetic zone Hunt outlined herpetic vesicles on the anterior two thirds of the tongue and over the fauces and soft palate in a region recognized as receiving fibers from the geniculate ganglion Thus he was able to define both the somatic and visceral areas belonging to that ganglion and the facial nerve Extension of the inflammatory process may involve the facial nerve and occasionally, the acoustic, giving rise to facial paralysis and auditory and vestibular signs *

Admittedly the cutaneous area about the ear served by the facial the glossopharyngeal and vagus nerves is vestigial In its embryologic development the external ear presents a complicated series of changes being formed by elements from the mandibular arch of the trigeminal the hyoid arch of the facial and in addition a free auricular fold of integument behind the hyoid portion containing areas served by the glossopharyngeal and vagus nerves and the second cervical segment It is not surprising therefore to find in this small area elements under the influence of all of these nerves for as has been repeatedly emphasized in these pages once a segment of skin belongs to a given nerve that innervation persists irrespective of the course and final disposition of the integument

The tragus and helix are developed from the mandibular arch and the antitragus antihelix and lobule from the hyoid The nerves to the external ear are the trigeminal the posterior auricular branch of the facial and the nerve of Arnold from the vagus which along with the auriculotemporal branch of the mandibular supplies the posterior wall of the external auditory canal reaching it through the tympano mastoid fissure

On its inner surface the lower three fourths of the auricle is supplied by the great auricular which also serves the outer surface of the lobule and adjacent area the upper fourth is supplied by the small occipital and by the auriculotemporal The

* Hunt s thesis rests primarily on clinical grounds Only five autopsies have been reported on patients with Hunt s syndrome of geniculate herpes zoster In two pathological changes were noted in the *geniculate ganglion* in two no changes were found and in one the geniculate ganglion was not included in the autopsy material Definite inflammatory changes were noted in the facial nerve in all five cases Unfortunately in none were the all important vagal and glossopharyngeal ganglia studied

canal and a small area on the posterior surface of the cleft between the ear and the mastoid process Thus he confirmed the persistence in man of a few somatic afferent fibers known to be present in the lower forms This somatic sensory distribution he attributed to the geniculate ganglion on the basis of the area involved in an herpetic eruption a criterion which had proved useful in determining the zone of innervation of some of the spinal ganglia and of the gasserian ganglion of the trigeminal

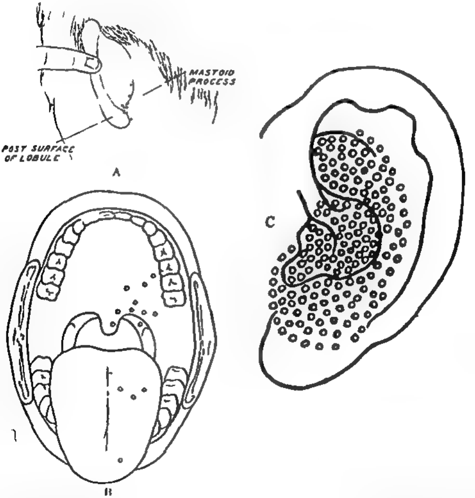

Fig 38 Diagrammatic representation of herpetic vesicles indicating the sensory field of the geniculate ganglion J Ramsay Hunt American Medical Association *Arch Neurol & Psychiat* 1937 Courtesy American Medical Association Chicago

oxysmal and intermittent in front and later in the depth of the ear It then became more constant, lasting for two to three hours associated with stabbing attacks and at times referred to the whole face The patient was seen by three different neurologists all of whom agreed as to the diagnosis and recommended operation Postoperative sensory examination as was anticipated showed no well defined disturbance but only lessened sensitivity in the auricular zone Unfortunately in this unique opportunity no study of gustatory sense was made by either Clark or Taylor One year after the operation there was partial recovery from the facial paralysis induced by the operation with no return of pain Six years later further recovery of the paralysis was noted and the patient was still free of pain thus confirming its geniculate origin

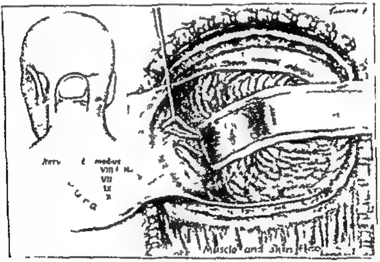

Fig 39 Exposure of the cerebellopontine angle method of separation of nerves and section of nervus intermedius Inset shows cutaneous incision and area of bone removal Furlow *J A M A* May 16 1942 Courtesy American Medical Association Chicago

Furlow (1942) reported successful section of the nervus intermedius for severe paroxysmal pain referred to the ear with occasional radiation about the left eye neither soreness of the deep tissues of the face nor radiation of pain into the throat was present A small area in the upper posterior quadrant of the external canal acted as a trigger area Cocainization of this region gave relief as long as the local anaesthetic effect lasted

muscles of the ear being derived from the platysma, are supplied by the facial

From a clinical standpoint accurate sensory distribution cannot be assigned to any one nerve Sensory loss about the ear ensues however after trigeminal tractotomy thus affording experimental proof of the evidence deduced from comparative anatomy that these vestigial components leave their respective nerves on entering the brain stem to join the somatic descending trigeminal tract These considerations make clear the difficulty of determining by section of a single nerve what area belongs to any one nerve and indicate the superiority of the herpetic distribution which Hunt found to be fairly constant for that purpose

In evaluating the symptoms of geniculate neuralgia Hunt stressed the importance of being aware of the complete geniculate afferent distribution since as in trigeminal neuralgia one part may be involved without implication of the whole nerve He lists the following components of the geniculate afferent system

1 Sensory filaments passing from the geniculate ganglion through the trunk of the facial to the tympanum and the cutaneous area on the external ear

2 Sensory fibers of the great superficial petrosal *via* the sphenopalatine ganglion where they are in relation with its orbital posterior nasal and palatal branches

3 Fibers of deep sensibility of the face which originate in the cells of the geniculate ganglion and pass with the peripheral motor branches of the nerve to the facial musculature

4 The chorda tympani nerve which conveys fibers for taste and a vestigial remnant of fibers for common sensation to the anterior two thirds of the tongue

Thus within the range of the afferent fibers of the geniculate ganglion are included the external and internal ear the orbitonasopalatal regions and the facial musculature

The first section of the nervus intermedius for geniculate ganglion neuralgia was performed by Alfred Taylor and reported by Clark and Taylor (1909) before the American Neurological Association as a physiological extirpation of the geniculate ganglion At the onset of the disease the pain was par

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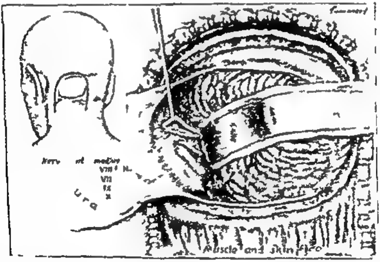

Fig 89 Exposure of the cerebellopontine angle method of separation of nerves and section of nervus intermedius Inset shows cutaneous incision and area of bone removal Furlow *J A M A* May 16 1942 Courtesy American Medical Association Chicago

Furlow (1942) reported successful section of the nervus intermedius for severe paroxysmal pain referred to the ear with occasional radiation about the left eye neither soreness of the deep tissues of the face nor radiation of pain into the throat was present A small area in the upper posterior quadrant of the external canal acted as a trigger area Cocainization of this region gave relief as long as the local anaesthetic effect lasted

At operation under local anaesthesia reproduction of the pain occurred when the nervus intermedius was touched but not when the glossopharyngeal was tested Furlow was able to separate the intermedius from the motor facial as well as from the acoustic and to section the intermedius At the end of the operation the patient had no evidence of facial weakness During the operation the anaesthetist touched the external auditory canal with a cotton swab without producing any pain Previous application of this stimulus had evoked an acute paroxysm

Not only did the patient obtain complete relief following the operation but in a personal communication Furlow informs us that six years later she had experienced no return of pain (no further follow up was possible) There can thus be no doubt as to the diagnosis in this instance and the efficacy of isolated section of the nervus intermedius Postoperative tests for lacrimation revealed no change on either side parotid secretion was also essentially equal on both the left and right though the submaxillary and sublingual glands showed some functional impairment on the operated side Taste was lost on the anterior two thirds of the tongue for salt bitter and sweet and there was hypaesthesia of the tympanic membrane and the adjacent part of the external auditory canal

This interesting case confirms the opinion of Hunt and the conclusion reached by Clark and Taylor

Wilson (1950) reported a case in which the nervus intermedius was cut with complete relief of pain Unfortunately however a definite evaluation of the operation was impossible since the patient had had an avulsion of the second division a differential section of the trigeminal dorsal root and section of the glossopharyngeal as well as of the nervus intermedius When the latter two nerves were exposed pain persisted after section of the glossopharyngeal but ceased after section of the intermedius

This patient s pain was constant deep in the ear spreading to the eye face cheek and over the nose and described as a dull ache in the ear as though the ear were going to burst In a personal communication Dr Wilson reported the patient free of pain eight and one half years after operation

Rosen (1953) reported two cases of neuralgia of the chorda

tympani relieved by section of that nerve By a very ingenious procedure under local anaesthesia the ear drum was lifted out of its sulcus and folded upward exposing the tympanic cavity (a technique used by Rosen in Meniere's disease) the chorda tympani and Jacobson's nerve Each of the nerves was stimulated with a bipolar electrode On stimulation of Jacobson's nerve pain was referred to the back of the ear and throat but did not resemble the pain in the ear whereas when the chorda tympani was stimulated the patient replied that is exactly like my ear pain

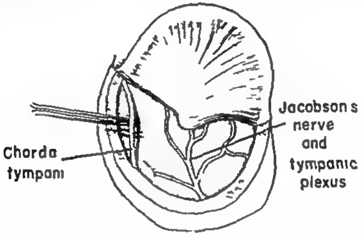

Fig 40 Exposure of the chorda tympani and Jacobson's nerve After the drum membrane is lifted out of its sulcus it is folded upward thus exposing the chorda tympani which is seen resting on the bipolar electrode during electrical stimulation The grooves on the inner tympanic wall containing Jacobson's nerve and other branches of the tympanic plexus can be seen Modified after Rosen *Arch Neurol & Psychiat* 1953 Courtesy American Medical Association Chicago

Both patients were completely relieved at the time of Rosen's report in March 1953 nine months after operation and in a personal communication Rosen informed us that one of them remained free of pain for two years after which she moved abroad and he lost sight of her

Since section of the chorda tympani or of Jacobson's nerve is distal to the cells of origin it is comparable to peripheral section of the trigeminal branches in which recurrence of pain is the rule Permanent relief can be obtained only by intracranial section proximal to the ganglion cells

With herpetic involvement of the geniculate ganglion there is

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for the infrequent recognition of the condition It may well be that some of the so called atypical neuralgias will be found to belong to the geniculate ganglion neuralgias In doubtful cases a suboccipital exposure under local anesthesia would permit gentle stimulation of either the nervus intermedius or the glossopharyngeal to induce an attack thus suggesting which nerve should be sectioned as was demonstrated by Reichert in glossopharyngeal neuralgia

Sphenopalatine Ganglion Neuralgia

Sphenopalatine neuralgia described by Sluder in 1908 and in subsequent communications has occasionally been referred to as lower half headache While not resembling major trigeminal neuralgia it presents symptoms which may be classified as an atypical form of that condition The patients complain primarily of deep-seated pain in the face (about the eye and root of the nose) in the upper jaw and in and about the ear Affected also is a point about 5 cm behind the mastoid sometimes with extension to the occiput and neck In some cases there are associated secretory and vasomotor symptoms congestion of the nasal mucosa and increased secretion Sluder attributed the disease to infection of the sphenoidal and ethmoidal sinuses with secondary involvement of the sphenopalatine ganglion His conclusion that the major part of the syndrome was attributable to the sphenopalatine ganglion has not been generally supported yet the fact remains that this ganglion though its own contribution is essentially secretory and vasomotor is an important cross road for nerve fibers of widely varying origin and distribution This symptom complex should be studied in the light of the geniculate ganglion otalgia and prosopalgia described by Hunt

In a number of our patients presenting some of the characteristics of Sluder s syndrome immediate and complete relief of symptoms has been obtained by cocainization of the region of the sphenopalatine ganglion Generally an epinephrine spray in the nose should be given to shrink the tissues followed by the application of a swab of cotton dipped in 4 per cent cocaine to the posterior and upper part of the middle turbinate A second application may be required if the pain is not relieved within a

almost always an associated paralysis of the facial nerve possibly due to swelling of the ganglion and pressure upon the nerve Postherpetic pain is apparently rare Hunt however had a patient in whom pain persisted for a matter of years after the disappearance of other symptoms In this instance there was violent pain in the ear at the onset with herpetic eruption in the external auditory canal and external auditory meatus At the same time a facial paralysis developed with loss of taste on the anterior two thirds of the tongue In a few weeks the facial palsy practically disappeared and taste returned but pain in the ear was severe for six weeks gradually diminishing but persisting for some years as an ache in the ear and over the face particularly over the cheek Postherpetic pain may thus involve not only the ear but the deeper structures of the face as well

Hunt divided geniculate neuralgia into two forms—(1) otolgic involving the ear (2) prosopalgia affecting the face In the otolgic form the pain is localized chiefly in the depths of the ear with some radiation to the face in the facial or prosopalgic variety the pain is primarily in the deeper structures of the face the orbit and the posterior nasal and palatal regions

Though trigeminal glossopharyngeal and even laryngeal neuralgias are well recognized Hunt believed that neuralgia of the important sensory system of the geniculate ganglion is often overlooked being included among the atypical facial neuralgias He stressed the importance of considering neuralgia of the geniculate sensory system in the differential diagnosis of these cases

Hunt s stimulating study indicates the desirability of a more determined approach to an understanding of so called atypical neuralgias which might fall within the algias of the facial nerve Because of the vagueness of the syndrome however and our failure to recognize it as a definite entity together with the technical difficulties involved in operating upon the nervus intermedius with the possibility of damage to the important and intimately related motor facial and acoustic nerve structures the surgeon has been reluctant to operate The indefinite character of the syndrome as suggested above is a logical outcome of the complexity of the afferent system with its ill defined and widespread connections It is this that has been responsible

grimaces It is made worse by eating and chewing It is referred to the second or third trigeminal divisions usually the latter and is often relieved by heat

The diagnosis is made by deep pressure with the examiner s thumb upon the temporal or masseter muscle until a discrete and exquisitely tender myositic nodule is found When this occurs the pain much to the patient s annoyance is promptly reproduced being referred to the area of the face in which it was originally experienced

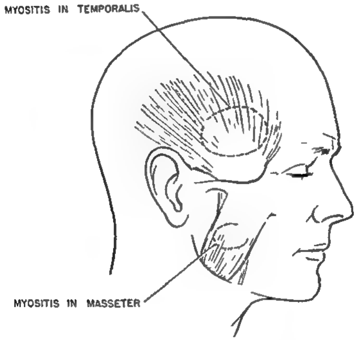

Fig 41 Usual location of myositic nodule in the temporal and masseter muscle

This syndrome closely resembles some forms of sciatic pain due to myositis of the gluteal muscles and pain in the arm due to localized myositis in the infraspinatus muscle The patients are relieved in the same manner by massage being careful to massage the small myositic nodule thoroughly followed by the application of ordinary heat microtherm or diathermy The first few massage treatments will make the pain worse but with repetition relief will be obtained Occasionally injection of 1 per cent procaine into the myositic nodule will be of help and hasten recovery Temporal and masseter myositis is a definite clinical

few minutes Too frequently this simple procedure is neglected and the patient is considered neurotic and referred elsewhere We have seen a number of cases in which temporary relief was afforded by this easy and innocuous clinical measure

It is probable that a few of the so called sphenopalatine neuralgias actually belong to the neuralgias of the geniculate ganglion Where the main symptoms are vasomotor and secretory with congestion of the nasal mucous membrane increased secretion and protracted sneezing they actually represent allergic manifestations and are not to be attributed to the sphenopalatine ganglion except indirectly

Ruskin (1925) after a careful critical analysis of the so-called sphenopalatine ganglion syndrome concluded as have most neurosurgeons that it does not represent a definite clinical entity He divided the symptoms into four groups maxillary, facial sympathetic and sphenopalatine occurring in a variety of combinations

Cox (1932) believed that Sluder s neuralgia was secondary to infection of the paranasal sinuses affecting however the nasociliary nerve rather than the sphenopalatine ganglion One patient upon whom three operations had been performed was not relieved of pain until the afferent impulses through the nasociliary nerve as tested by the corneal reflex were abolished Lubosch (1928) held that the nasociliary nerve in man represents the deep ophthalmic phylogentically the nerve of the first branchial arch and as now constituted containing fibers from both the ophthalmic and maxillary divisions thus representing an old afferent facial system It is neuralgia of this system to which Cox attributes Sluder s neuralgia

Temporal and Masseter Myositis Simulating Trigeminal Neuralgia

A number of patients have been referred by competent neurologists because of pain almost typical of trigeminal neuralgia but actually due to myositis of the temporal or masseter muscles or both The pain is generally more constant but may be paroxysmal it is not as sharp nor is it accompanied by facial

forty two years complained of rapid and sudden onset of complete numbness of one side of the face including the forehead eye, lips and tongue Even biting the lips or tongue was painless The anaesthesia lasted from a few weeks to four years and in each case passed off *completely*, being succeeded by paroxysmal spasms of pain of sudden onset but not by eating or touching the face and yielding to alcohol injection

Because of the age of these patients Harris eliminated multiple sclerosis as the aetiological factor It is possible that such sudden anaesthesia with subsequent complete recovery may represent allergic phenomena occasionally seen in other parts of the central nervous system

Another interesting and unusual case was reported by Frazier (1924) His patient had paroxysms of pain during which he grabbed his cheek even *while asleep* These episodes were observed both by the referring physician and during several nights in the University Hospital prior to operation Complete avulsion of the trigeminal sensory root abolished this symptom as well as the pain

Campbell and Keedy (1947) described two patients having hemifacial spasm associated with trigeminal neuralgia Both had cirsoid aneurysms of the basilar artery It was suggested that hemifacial spasm may be due to such vascular anomalies

In the presence of facial tic it occurred to the senior author that the tic might be eliminated if the afferent arc were destroved assuming that the tic were on a reflex basis A patient was seen in 1935 who had facial tic beginning in 1923 Six years later trigeminal neuralgia developed on the same side The tic had spread to involve the entire facial musculature The pain was typical paroxysmal trigeminal pain occurring both with and without facial spasms Complete dorsal root section abolished the pain but the tic continued unabated

entity, which unfortunately is frequently overlooked and presents some of the signs found in disturbances of the bite mechanism

Alteration in the mechanics of the temporo mandibular joint the so called Costen syndrome, has in a measure replaced dental extraction as a probable source of trigeminal pain While the joint may be tender the pain is diffuse usually constant and de scribed as a dull ache though it may appear suddenly on extreme movements of the jaw as in yawning A trigger mechanism such as arises on gently touching the lips or nose is not present

Schwartz (1956), in a thorough study of the temporo mandib ular joint pain syndrome was unable to establish the symptom complex described by Costen (1934) who believed that over closure of the jaws followed loss of the posterior teeth Costen believed the defect could be corrected and the normal condylar glenoid relations restored by raising the bite mechanism Schwartz believed the symptoms were due to muscle tenderness and spasm of the antigravity muscles especially the masseter temporal and internal pterygoid His cases closely resemble those of masseter and temporal myositis which we have treated successfully for years by massage heat and procaine injections In some of his cases emotional and tensional factors were dominant Unfortunately a number of patients having true trigeminal neuralgia have undergone extensive dental work designed to alter the bite mechanism with obviously no relief

As far as we are aware pain due to diseased teeth never produces paroxysmal pain such as is seen in typical trigeminal neuralgia Yet on the insistence of the patient sound teeth are so frequently extracted that it is relatively unusual to see a patient who has not had some or all teeth extracted in the vain hope that the pain would be abolished If localized dental disease is found it should be of course be corrected yet true trigeminal pain in our experience is not due to this cause Extraction of sound teeth however urgent the demand of the patient should never be done

Rare and Unusual Cases

Among the rare and unusual cases three reported by Harris (1935) are of interest Patients aged seventy five sixty five and

but at the entrance zone of the *left* root two plaques were found One of these extended a short distance into the fibers outside the pons after which normal fibers were again seen up to the point of section of the dorsal root Both gasserian ganglia and their divisions were normal

Sclerotic plaques in the descending root and the main sensory nucleus have been found in a number of autopsies without associated paroxysmal pain In all those cases with paroxysmal pain however the plaques were at the entry zone Parker thought that this might be a particular algegenic area and called attention to pain produced by pressure or manipulation of the dorsal roots whether cranial or spinal He mentioned also the sharply localized lightning pains of tabes of the central nervous system the initial lesion of which has been said to be at the point of entrance of the posterior root fibers into the dorsal columns of the spinal cord

Berger (1905) reported two cases of trigeminal pain among 206 patients with multiple sclerosis In one of these it was the initial complaint Two examples with an onset marked by facial pain were also found by Carter Sciarra and Merritt (1950) in a review of forty two controlled autopsy cases Wilson (1941) on the other hand in a study of 539 cases with special attention to the early symptoms encountered none in which the first sign was pain in the face

In spite of conflicting reports it appears obvious that in rare instances typical trigeminal pain may be the presenting symptom in multiple sclerosis and remain the sole evidence of the disease for a period of time This should be borne in mind when paroxysmal facial pain appears especially between the ages of twenty and forty when multiple sclerosis is most likely to develop In other instances pain may develop later in the course of the disease and continue throughout the illness The surgeon must thus be alert to consider multiple sclerosis in his differential diagnosis Whether trigeminal dorsal root section be done at the onset or during the later stages it is the only measure which will give permanent relief and make the disease less burdensome

The incidence of multiple sclerosis in patients in whom the primary diagnosis was trigeminal neuralgia has also been variously reported Harris (1940) in his series of 1 433 patients with

CHAPTER V

PAROXYSMAL TRIGEMINAL PAIN IN MULTIPLE SCLEROSIS

It has long been recognized that pain may be the first symptom of multiple sclerosis and that, once established, it may continue throughout the course of the disease. Muller (1910) designated this form *sclerosis multiplex dolorosa*. In rare instances the pain may be of the typical paroxysmal trigeminal type. Marburg (1909) reported such a case with the finding at autopsy of a sclerotic plaque at the site of entry of the trigeminal dorsal root into the pons. Oppenheim (1911) made a similar observation.

Parker (1928) reported four cases of typical multiple sclerosis with characteristic trigeminal pain occurring during the course of the disease; in two it was present almost from the beginning. In one patient all divisions of the trigeminal were involved, in two the maxillary and mandibular, and in the fourth only the mandibular. In one of these cases autopsy was performed and a sclerotic plaque was found in the entry zone of the trigeminal root, extending into the root a short distance before its entrance into the pons. This patient had suffered from multiple sclerosis for fourteen years before the development of the pain, which lasted for six years and was indistinguishable from true trigeminal neuralgia. The attacks were initiated by touching the face, eating and drinking; the paroxysms alternated with periods of remission. There were no objective signs referable to the trigeminal nerve. Because of the patient's pitiful state and in spite of her poor condition, Adson cut the *left* trigeminal dorsal root. Death ensued four days later and autopsy revealed sclerotic plaques in the spinal root and nucleus of the *right* trigeminal nerve. Serial sectioning of the pons throughout its extent showed abnormalities in the *left* fifth nerve nucleus. The intrapontine course of both roots was normal, with normal staining myelin

divisions were involved in two patients and in the other the right second and third with secondary radiation into the first division In one instance the disease had been present seventeen years before trigeminal pain appeared In no case was the pain bilateral Because of the nature of the underlying disease and the likelihood of spread to all divisions it was considered best to do a total rather than a differential section sparing the motor root

trigeminal neuralgia found fifty or 3.48 per cent who had multiple sclerosis or "other forms of spastic paralysis." Unfortunately the inclusion of these "other forms of spastic paralysis" precludes an accurate estimate of the association of the two diseases under consideration. Of the fifty cases seven, or 14 per cent, were bilateral. This high incidence of bilateral trigeminal pain Harris believed was to be attributed to sclerotic patches in the descending root within the medulla and pons which irritated or rendered the pain fibers hypersensitive in individuals whose peripheral nerve endings were vulnerable as a result of dental or sinus infections.

In commenting on the frequency of multiple sclerosis as mentioned in an earlier account by Harris (1926), Frazier (1934) stated that he was unable to recall any case of major neuralgia in a patient with multiple sclerosis though he had done at that time 875 trigeminal dorsal root sections and had records of 2,198 cases designated as major trigeminal neuralgia. Peet and Schneider (1952) in their series of 689 cases of trigeminal neuralgia and 553 operations did not include any with multiple sclerosis. Horrax and Poppen (1935) reported three examples of multiple sclerosis in their series of 475 cases but made no statement as to whether operation was performed.

A possible explanation of the failure to recognize the presence of multiple sclerosis is suggested by Harris's reference to the reluctance of some patients to mention any weakness of the legs unless especially questioned, even though they may have had difficulty in walking for a year or more and plantar responses will be found on examination to be extensor. Multiple sclerosis occurring in his own series, however, was usually obvious.

In our series of 728 operated cases there were five of multiple sclerosis, representing 0.68 per cent of the total, and in only one of these, in a female aged forty, was trigeminal pain the presenting symptom. On examination, however, sufficient signs indicative of multiple sclerosis were found to establish that diagnosis though the patient had not been aware of any of the neural deficits encountered. In each case the pain was typical of trigeminal neuralgia, being paroxysmal and induced by eating, chewing, washing the face, or by a draft of air. The left second and third

in twenty varicella vesicles occurred locally at the site of the injection Bruusgaard (1932) inoculated eighteen children intra dermally with material from zoster vesicles four showed a general exanthem and four a local eruption typical of varicella While long lasting immunity occurs in varicella and in zoster immunity to one does not give immunity to the other It is doubtful if the viruses are identical though they are probably closely related

The pathological changes in herpes zoster are primarily in the ganglion However the virus extends centrally along the dorsal root to involve the entry zone and the dorsal horn and, in the brain stem the nuclei of the trigeminal It is probably this central extension of the disease process which accounts for the poor results obtained by dorsal root section in the surgical treat ment of ophthalmic zoster The ganglia show cellular infiltration, exudates and bloody effusion the ganglion cells are swollen and diffusely stained

Since herpes zoster is an infective disease it is of particular interest that the ophthalmic portion of the ganglion is infected without spill over into the immediately adjacent maxillo mandib ular ganglion cells Such selective activity is hard to explain One cannot help recalling however that the ophthalmic ganglion arose independently, only later in the course of phylogenetic development uniting with the maxillo-mandibular to form the gasserian ganglion In trigeminal neuralgia the ratio of involve ment of the ophthalmic division to that of the other divisions is approximately 5 to 95 In herpes zoster the proportions are reversed What role if any the dual origin of the gasserian ganglion may play is not clear yet the fact remains that the two portions of the nerve exhibit a different susceptibility to trigeminal neuralgia and to herpes zoster

The herpetic pain may be confusing until vesicles appear establishing the diagnosis In the early stages pain is usually con trolled by a variety of anodynes such as aspirin combined with codeine The rash should be dusted with zinc oxide and talc and dry dressings should be applied Marshall (1955) found topical application of 1 per cent hydrocortisone ointment twice daily highly effective in relieving pain and alleviating the skin lesions Weintraub (1955) following the work of Gros (1952)

CHAPTER VI

HERPES ZOSTER

Herpes zoster may involve any one of the trigeminal divisions but the ophthalmic is by far the most frequently affected, implication of the second and third divisions being extremely rare. The supraorbital and supratrochlear areas are fortunately more commonly involved than the lacrimal and nasociliary. When the latter nerve is affected, serious ocular complications may arise as keratitis, corneal ulcers, or even a secondary panophthalmitis. In rare instances, weakness of the muscles supplied by the oculomotor nerve is found.

The vesicles of herpes zoster appear first in sequence along the course of the supraorbital and supratrochlear nerves as erythematous papules, followed by pustules and crust formation. Pain, usually described as an ache or burning sensation, may be present before the appearance of the vesicles. The effects are generally local and rarely systemic. The older age group is most commonly affected. The vesicles are large, in contrast to the small vesicles of herpes simplex, which are usually found in the labial region rather than in the ophthalmic distribution. Ophthalmic herpes zoster is always unilateral, occurring only once in the same individual.

Unlike the virus of herpes simplex, the zoster virus when inoculated in the scarified cornea of the rabbit produces no response. It is thought to be closely related to the virus of chicken pox. Von Bokay (1909) first called attention to the close association of varicella and herpes zoster. Cases of chickenpox have developed after exposure to herpes zoster and herpes zoster has been seen following contact with chickenpox, though less commonly. Kundratitz (1925) inoculated fifty children under the age of six with herpetic vesicular fluid and nine to twelve days later twenty-six showed either a local or general reaction. In five a general exanthem identical with varicella appeared and

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The pathological changes in herpes zoster are primarily in the ganglion However the virus extends centrally along the dorsal root to involve the entry zone and the dorsal horn and, in the brain stem the nuclei of the trigeminal It is probably this central extension of the disease process which accounts for the poor results obtained by dorsal root section in the surgical treatment of ophthalmic zoster The ganglia show cellular infiltration exudates and bloody effusion the ganglion cells are swollen and diffusely stained

Since herpes zoster is an infective disease it is of particular interest that the ophthalmic portion of the ganglion is infected without spill over into the immediately adjacent maxillo mandibular ganglion cells Such selective activity is hard to explain One cannot help recalling however, that the ophthalmic ganglion arose independently only later in the course of phylogenetic development uniting with the maxillo-mandibular to form the gasserian ganglion In trigeminal neuralgia the ratio of involvement of the ophthalmic division to that of the other divisions is approximately 5 to 95 In herpes zoster the proportions are reversed What role if any the dual origin of the gasserian ganglion may play is not clear yet the fact remains that the two portions of the nerve exhibit a different susceptibility to trigeminal neuralgia and to herpes zoster

The herpetic pain may be confusing until vesicles appear establishing the diagnosis In the early stages pain is usually controlled by a variety of anodynes such as aspirin combined with codeine The rash should be dusted with zinc oxide and talc and dry dressings should be applied Marshall (1955) found topical application of 1 per cent hydrocortisone ointment twice daily highly effective in relieving pain and alleviating the skin lesions Weintraub (1955) following the work of Gros (1952)

reported dramatic relief of pain following injection of gamma globulin, the skin lesions showed no further progress and healed without scarring An initial injection of 10 cc of gamma globulin was given intramuscularly half the dose in each buttock followed by 5 cc every second day until the pain ceased and the vesicles be gan to disappear Roentgen therapy given in the early stages to the region of the gasserian ganglion usually 200 r every other day for three or four treatments has been helpful Postherpetic pain rarely develops after roentgen therapy has been given providing treatment is begun early

Fig 42 Ophthalmic herpes zoster

While most patients recover in four to six weeks without complications in a few the herpetic pain may persist and gradually become more severe The patient complains of a sensation of burn ing and crawling and a sense of tightness The pain is constant night and day without remissions though not as severe or par oxysmal as in trigeminal neuralgia It occurs more often in elderly patients sapping their resistance and making life unbearable

Neither dorsal root section nor peripheral evulsion of the supraorbital nerve for postherpetic pain involving the ophthalmic

division has been of value On the contrary the added anaesthesia and dysaesthesias serve only to make the patient worse It is obvious that if the disease process has involved the entry zone and the trigeminal nucleus little can be expected from dorsal root section In our experience no form of operative interference has proved of value in ophthalmic herpes zoster While an occasional patient may be benefited by one or the other of the operative procedures relief has not been consistently obtained These procedures include operations upon the primary neuron, whether peripheral or central and incision of the skin of the frontal region through the skin down to the periosteum

Sugar and Bucy (1951) made a thorough review of the various procedures employed and assembled data from members of the American Board of Neurological Surgery Of eighty cases treated by various methods including dorsal root section avulsion of the supraorbital alcohol injection trigeminal tractotomy cervical sympathectomy stellate block and x ray treatment good results or cure were obtained in only eight two by dorsal root section three by avulsion of the supraorbital one by alcohol injection into the gasserian ganglion one by irradiation of the gasserian ganglion and one by cervical sympathectomy Sugar and Bucy concluded as have most neurological surgeons that all forms of medical and surgical therapy have been of little value except possibly bilateral frontal lobotomy The drastic alterations in the patient s personality which follow this operation make the end attained worse than the painful affliction Fortunately the pain gradually diminishes though in some instances it may last for several years

Since the morbid process of herpes zoster affects primarily the ganglion and since the ganglion is not destroyed by dorsal root section it is possible though extremely unusual for herpes zoster to develop after dorsal root section One patient was seen by the senior author with typical zoster vesicles and subsequent scarring Bucy has reported one such case and Gardner (1952) one Pain was not present in the author s patient

CHAPTER VII

TRIGEMINAL TUMORS AND THEIR RELATION TO TRIGEMINAL NEURALGIA

A few tumors have been described arising from the trigeminal root the gasserian ganglion or its divisions in the subtemporal region producing pain which might be confused with trigeminal neuralgia Weisenberg s (1910) case of a tumor in the posterior fossa originating on the glossopharyngeal root will be discussed later (p 248) Dandy s (1945) statement that 10 per cent of his series of operations revealed unsuspected neoplasms as the cause of trigeminal pain and Alexander s (1947) report of a case of central neurofibromatosis presenting as trigeminal neuralgia suggest the desirability of a review of the entire subject of trigeminal tumors and their relation to pain in that nerve

Tumors arising from the gasserian ganglion and its divisions in the subtemporal region or on the root in the posterior fossa admittedly may produce pain To simulate major trigeminal neuralgia however the pain must have the characteristics of that disease it must be paroxysmal with remissions of varying duration it must be unaccompanied by subjective or objective sensory changes or motor weakness of the muscles of mastication A review of the reported cases of trigeminal tumors with possibly few exceptions shows that confusion in diagnosis need not arise if a sufficient history of the onset and course of the disease be given and an adequate examination made

Tumors in the group under consideration fall into three general categories (A) tumors involving the trigeminal nerve secondarily (B) meningiomas arising in the dural sheath investing the nerve (C) primary trigeminal tumors

A *Tumors involving the trigeminal nerve secondarily* include invasive neoplasms from the nasopharynx extending along the

internal carotid or eroding through the floor of the middle fossa—either primary or metastatic carcinoma or sarcoma—and locally malignant growths arising from the ganglion, the neurocytoma of Marchand Meningiomas osteomas or chondromas arising in the middle fossa may cause compression of the trigeminal ganglion and its divisions and tumors in the cerebellopontile angle when they have attained sufficient size may compress or stretch the dorsal root and produce pain

The malignant tumors cause excruciating pain constant in character without remission in no wise resembling the pain of trigeminal neuralgia except that the distribution may be within the trigeminal area Subjective or objective sensory changes or both are usually present in one or more divisions A detailed examination including roentgen studies of the base of the skull will generally rule out trigeminal neuralgia and establish the diagnosis In this group the character of the pain is such that it is doubtful if trigeminal neuralgia would be considered in the differential diagnosis

Sachs (1917) and Cushing (1920) described large meningiomas in the middle fossa compressing the ganglion to paper thinness In one of these cases even though cerebral herniations were forced into the foramen ovale and rotundum the patient never complained of pain

B *Meningiomas arising from the arachnoid villi* within the dural sheath investing the trigeminal are not common Cushing and Eisenhardt (1938) in their series of 294 proven meningiomas found only five Ver Brugghen (1952) reported three examples one of which was unsuspected at operation One of ours was also unsuspected and found at operation

These tumors are relatively slow in growth gradually compressing the ganglion and nerve fibers producing numbness and dysaesthesia Paroxysmal pain may be present in the *initial* stage but as pointed out by Ver Brugghen is soon accompanied by either subjective or objective sensory findings If the tumor is in the middle fossa and sufficiently large ipsilateral ocular signs appear if it has extended into the posterior fossa the signs may suggest an angle tumor In the five cases reported by Cushing and Eisenhardt the findings were such that trigeminal neuralgia

was not considered in the diagnosis The tumors were large in vading both the middle and the posterior fossa Ver Brugghen s meningiomas fortunately were small were diagnosed early before the involvement of neighboring structures and, as he pointed out could not have been dealt with *via* the posterior approach

An unsuspected and unusual finding was reported by Love and Woltman (1942) in a patient with a history of paroxysmal pain in the right mandibular division relieved by alcohol injec tion Exposure of the dorsal root in the subtemporal region revealed a small epidermoid This occupied the center of the root with nerve fibers both above and below it and was easily removed It is the only epidermoid in the series under review

C . *Primary trigeminal tumors,* the so called neurinomas arise from the nerve sheath They have been designated schwannomas by some Others assigning their origin to the endoneurium and peri neurium have termed them neurofibromas Learmonth and Kernohan (1930) thought it best that they be designated simply as sheath tumors

Altmann (1928) studied two primary trigeminal tumors found at autopsy with their anatomical relationships undisturbed One arose from the gasserian ganglion at the origin of the third division while the second originated immediately distal to the ganglion in the third division In neither was the motor root involved Antoni (1920) speaking of spinal cord tumors called attention to the frequency with which such tumors arise on the dorsal root as compared with the ventral root Since the majority of the sheath cells migrate from the ganglionic crest along the nerve fibers of the dorsal root it may well be that a few cells are held at or near the ganglion constituting a residual cluster from which these tumors may develop

As is well known tumors are not infrequently found on the peripheral branches Cases reported by Learmonth and Kernohan and by Cuneo and Rand (1952) suggested a peripheral origin In the case of Cuneo and Rand such an origin was established roentgenologically since an extraordinary enlargement of the inferior dental canal and mental foramen was demonstrated In addition there was numbness of the lower lip before any in volvement of the muscles of mastication or the appearance of

other trigeminal nerve signs indicative of a peripheral lesion

A masterful survey of this entire subject by Jefferson (1955) will long stand as a definitive contribution He found reports of twenty six trigeminal neurinomas which he believed to be clinically and histologically acceptable and to these added six of his own bringing the total to thirty two proven cases This number should be further augmented by two examples reported by Cushing and Eisenhardt extending into the middle and posterior fossae and by the sheath neurinoma reported by Learmonth and Kernohan and the schwannoma described by Cuneo and Rand both of which were in the middle fossa

A comprehensive study of thirteen trigeminal neurofibromas from the Mayo Clinic was made by Olive and Svien (1957) Six were in the middle fossa four were infratentorial and three were dumbbell tumors involving both middle and posterior fossae Pain in the trigeminal area was the presenting symptom in only one of the thirteen cases In fact pain as a symptom was conspicuously absent in the group Numbness in the distribution of the trigeminal was present in three of the middle fossa cases in three of the posterior fossa and in only one of the dumbbell tumor group Numbness and objective sensory disturbances occurred in the majority The one patient whose presenting symptom was pain complained of dull pain of three years duration in front of and within the auditory canal which gradually became worse It was associated with intermittent sharp shooting pain along the ramus of the mandible The neurological and otological examinations were negative as was also x ray examination of the skull but films of the cervical spine showed narrowing of the fifth inter space In view of this finding it was thought that the pain arose from the cervical region and was treated accordingly A year later weakness of the motor division was noted yet the sensory examination and corneal reflexes were still normal When the patient was eventually operated upon a cystic neurofibroma was found in the middle fossa associated with the second division

A review of the files of the Neurological Institute of New York revealed two examples of schwannoma of the trigeminal nerve From the case records and the signs present these appear to have been saddle tumors with a mass in both the middle and posterior

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the gasserian ganglion found pain to be present in seventeen with impairment of sensation in sixteen motor weakness in thirteen, and absence of the corneal reflex in ten

Krayenbuhl (1936) collected from the literature fifty four tumors involving the gasserian ganglion and root On the basis of the pathological reports he found it possible to be certain of the exact origin of only twenty nine three from the dorsal root and twenty six from the ganglion The clinical history in two of the cases in the latter group was incomplete In the remaining twenty four arising from the ganglion pain in the face was severe burning and throbbing lasting throughout the illness whereas in the three cases originating in the dorsal root pain was absent in two and moderate in one Only one case was found that of Alajouanine de Martel and Guillaume (1930) in which pain was present from the beginning In evaluating the entire group of fifty four cases Krayenbuhl found that all the tumors with an onset pointing to an origin in the middle fossa produced severe pain in thirteen in which the tumor extended into the posterior fossa pain continued though in one of these it ceased after six months and in another after two years In contrast, among fifteen cases arising from the dorsal root in the posterior fossa pain was absent in eight slight in five and marked in only two If to this latter group we add the two personal cases reported by Krayenbuhl and two by Jefferson—a total of seventeen tumors originating primarily in the dorsal root— pain was absent in ten slight in five and marked in only two those of Sheldon (1921) and of Alajouanine de Martel and Guillaume (1930)

From a study of our own and the published cases it is apparent that pain is more often found in tumors of the ganglion than of the root The root lies free in the posterior fossa and tumors arising here are not held within an enclosed dural covering as are tumors within the dura propria of the ganglion Even though the tumor may occur primarily in the ganglion its extension into the posterior fossa where it is not rigidly *confined* is often larger than the original portion in the middle fossa though the growth of the latter is of longer duration Pain in tumors contained in the sheath about the ganglion may be the result of pressure exerted upon the ganglion by the relatively

fossae at the time of operation though they probably arose in the ganglion In neither instance could the tumor be completely removed In one the presenting symptom was numbness of one and a half year s duration without pain In the second case numbness associated with hyperaesthesia and pain was present for three years and a slight hearing loss developed shortly before the patient was admitted Trigeminal neuralgia was not considered in the diagnosis of either of these cases

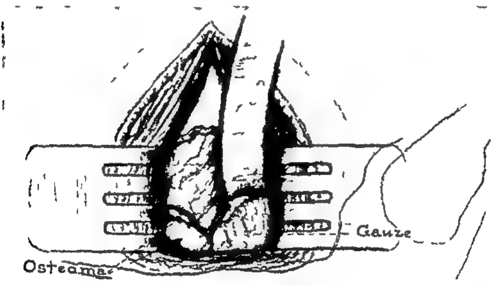

Fig 43 Osteoma arising from floor of middle fossa compressing the trigeminal root

Thus fifty one neurinomas have been collected others would no doubt be found were a survey made of the major neurosurgical clinics Jefferson divided the neurinomas into three groups on the basis of location (a) in the middle fossa (b) in the posterior fossa and (c) about equally in both Of his series twenty three were in the middle fossa fifteen were in the posterior fossa and thirteen involved both the middle and posterior fossa

In commenting upon the symptomatology of these tumors Jefferson stated that the only surprising thing about them if it is a surpise is that facial pain has not been a uniformly significant feature Some change in the cutaneous sensibility of the face is in fact more common than severe pain

Cooper (1933) in a review of twenty two tumors involving

CHAPTER VIII

THE NON SURGICAL TREATMENT OF TRIGEMINAL NEURALGIA

The search for a non surgical treatment of trigeminal neuralgia has engaged the attention of many physicians over a long period The literature is replete with reports attributing success to this remedy and that but none has stood the test of time Since freedom from attacks for as much as one or two years is not uncommon long term studies are required to establish the value of any measure Merritt (1955) has summarized the considered opinion of the majority as follows The medical treatment of trigeminal neuralgia has not proven to be of any value The pains are so severe that they are not relieved by analgesic drugs except morphia the use of which is contraindicated The inhalation of trichlorethylene may abort an attack but its benefits are inconsistent and unpredictable Frequent use of this drug may produce liver damage The good results which have been reported with the use of vitamins iron or other substances can be explained on the basis of the occurrence of a natural remission

One of the earliest remedies to be suggested was Peruvian bark recommended by Fothergill (1773) Quinine the chief alkaloid of the bark of the cinchona tree resembles the salicylates in its analgesic effects on the central nervous system (Goodman and Gilman 1955) It is probably this action which is responsible for the benefits reported

Hutchinson in 1820 gave an extensive review of medication then in use including blistering purging pills of conium maculatum muriate of mercury camphorated mercurial ointment ether opium and arsenic in gruel He considered four grains of ferrous carbonate (Blaud s pill) twice daily to be a valuable and highly curative mixture and widely recommended its use Davidoff revived this method of treatment stating in a

nonyielding dural covering The situation is analogous to that in tumors on the spinal nerve roots which are known to produce pain Here again we find that the dumbbell extension into the thorax or into the neck where the tumor can grow more freely is often larger than that portion contained within the rigid con fines of the intervertebral foramen and vertebral canal Trigem inal tumors in the posterior fossa may consequently attain con siderable size before their presence is signaled by pressure upon adjacent structures whereas middle fossa lesions may be mani fested by pain and destruction of the neuron by pressure pro ducing both subjective and objective sensory disturbances as well as motor disturbances of the muscles of mastication

The problem so far as it relates to trigeminal neuralgia is not whether pain is or is not present but whether it has the characteristics of that disease A study of trigeminal tumors indicates that only rarely is the pain due to this cause paroxysmal it is in general constant accompanied by either subjective or objective sensory changes—more often both—and in addition by atrophy and weakness of the muscles of mastication In only the rarest instances is there any resemblance to trigeminal neuralgia

In our series three patients or 0 42 per cent were operated upon with the preoperative diagnosis of trigeminal neuralgia In one a cyst compressing and dissecting the ganglion was found The pain had been paroxysmal in the maxillary and mandibular divisions with no sensory or motor signs A second patient had a small reddish tumor within the dura propria of the ganglion which was readily removed by suction It proved to be a menin gioma The pain was typically paroxysmal in character and without any associated organic signs The third patient several years later proved to have an angle tumor though no symptoms or signs had been evident at the time of the trigeminal operation Unfortunate ly neither caloric examination nor x rays of the internal auditory meatus had been made If the slightest doubt exists as to the diagnosis caloric tests and x ray studies of the base of the cranium are indicated If the possibility of tumor is borne in mind the diagnosis may be made earlier and a more favorable outcome achieved

Glaser (1931) summarized the literature on the use of this drug in 163 patients 15 per cent experienced complete relief and 52 per cent were partially helped He recommended inhalation of twenty to twenty five drops of trichlorethylene from a piece of gauze three times a day for a period of one month to six weeks and as a maintenance dose inhalation on three consecutive days of each week for an additional two or three months Attention was called to the toxic effects of trichlorethylene by McAuley (1943) who used the drug in the form of Trilene in patients undergoing general anaesthesia In a brief note in the British Medical Journal he described three cases with the following untoward manifestations numbness of the face loss of corneal reflexes dryness of the nostrils and speech difficulty characterized as lisping

Goodman and Gilman (1955) postulate that the analgesia obtained with this drug is due to a central depressant action The patient should therefore be reclining during inhalation since lassitude nausea and even transient unconsciousness may occur In addition serious cardiac arrhythmias including ventricular tachycardia and cardiac arrest have been noted by Waters (1943) and others As a halogenated hydrocarbon trichlorethylene shares with chloroform a potential toxic effect on the liver which however seems to be more common when the drug is employed as an anaesthetic rather than an analgesic agent We cannot recommend the prolonged use of this toxic agent especially in view of the possible production of bilateral facial anaesthesia in a patient with unilateral facial pain

Stilbamidine Another preparation whose possible usefulness in trigeminal neuralgia was suggested in connection with its use for a quite different purpose is stilbamidine Napier and Sen Gupta (1943) using this drug in the treatment of kala azar described bilateral trigeminal neuropathy two to five months following its administration Pain and touch sensation were diminished over the face and some patients developed intense formication and burning especially about the nose and eyelids These authors pointed out that exposure of the drug or the patient to ultra violet radiation was responsible for the development of toxic characteristics including the production of irreversible hepatic

brief note (1944) that he had found at least 50 per cent of paroxysmal trigeminal neuralgic pain to be relieved by this means Five years of experience however led him to conclude (1950) that while a considerable percentage of patients got temporary relief they eventually required some other form of treatment The number of patients included in his study was not mentioned There is no known pharmacological basis for the use of this preparation in trigeminal neuralgia

Sawyer and Mackey (1874) recommended powder of gelsemium macerated in a pint of rectified spirit Evidence of physiologic action was said to be loss of sight double vision headache and paralysis Galvanic treatments were used by Sinkler (1875) who claimed to have obtained relief in five of ten patients

Trichlorethylene Inhalations of trichlorethylene have been extensively used in attempts to abort the pain of trigeminal neuralgia Trichlorethylene a sweet smelling white liquid was widely used in Germany during World War I for removing grease from metal machinery Four men in whom inhalation of its fumes was followed by acute toxic manifestations were reported by Plessner (1915) Symptoms included vertigo vomiting swelling of the optic discs and bilateral loss of sensation in the distribution of the trigeminal nerve with sparing of the motor root At the time of Plessner s report some eight months after the onset of the condition the patients had recovered from the acute symptoms but were left with bilateral facial anaesthesia

Oppenheim who had heard of Plessner s original presentation suggested to him the use of the drug in trigeminal neuralgia Plessner was apparently favorably impressed by the idea and three years later (1918) presented seventeen patients treated by trichlorethylene inhalations all of whom were improved the time required for relief having been three to four weeks These patients were not reported to have facial anaesthesia The discrepancy between Plessner s original cases and those later treated by him and others in respect to the development of anaesthesia over the trigeminal distribution led von Kalinowsky (1927) to question whether some other substance inhaled along with the trichlorethylene may not have been responsible for the toxic manifestations in the original cases

(1954) administered 0 6 grams of diphenylhydantoin a day to thirty six patients halved the dose after five days of treatment for nine days and finally reduced it to 0 3 grams for an additional two weeks Sixteen patients experienced complete relief and significant improvement occurred in fifteen others None of these authors gives the length of follow up in the cases treated Schaltenbrandt (1957) claimed definite relief of trigeminal pain by 1 to 3 grams of dilantin a day but again the period of relief obtained is not specified

While the effect of hydantoins may be based on a central depressant action on a theoretically discharging focus the doses recommended are above the usual toxic levels and probably could not be tolerated for an extended period of time

Vitamin B In view of the relief of pain with vitamin B in pernicious anemia and in alcoholic diabetic and non specific peripheral neuritis Borsook (1940) treated fifty eight trigeminal neuralgia patients with 10 to 100 milligrams of this vitamin intramuscularly three times a week One half a cubic centimeter of crude liver extract was given with each injection Thirty seven patients were considered to be markedly improved fifteen improved three slightly helped and three unchanged The treatment was continued over a period of several months until relief was obtained and in some instances was maintained indefinitely The patients had been followed from six to fourteen months at the time of the report

Fields and Hoff (1952) using a considerably more potent solution than was previously available administered massive doses of vitamin B_{12} to patients with trigeminal neuralgia Marked relief of pain occurred in thirteen cases with complete remission in nine These patients were observed up to ten months without recurrence of pain In their last seven cases Fields and Hoff gave as much as 100 micrograms daily for ten days Alexander and Davis (1953) administered much larger doses to seventeen patients 1 000 micrograms daily for ten days While six were completely relieved and two 90 per cent relieved over a follow up period of two to eight months the authors were of the opinion that control studies were necessary to prove the efficacy of this therapy

and renal damage Arai and Snapper (1947) administered freshly prepared stilbamidine to twenty six patients for kala azar without the development of any renal or hepatic changes

Woodhall and Odom (1955) treated forty one patients with typical trigeminal neuralgia by daily intravenous injections of stilbamidine for a period of ten days Thirty six of the group were pain free from nine months to two years after treatment Lasting relief did not appear until some 40 to 150 days following the termination of treatment and during this waiting interval *the episodes of acute pain were as severe as prior to the institution* of therapy Two patients suffered recurrences after two and ten months respectively, one of these was relieved by repetition of the treatment and the other was operated upon Six other patients required a second course of therapy and three were subsequently treated by surgical methods

The bilateral trigeminal neuropathy which developed in the successfully treated cases had two main characteristics numbness or leathery feeling in the face and paraesthesias such as itching burning tingling and watering of the eyes Corneal sensation was preserved but trigger zones were abolished All patients with loss of pain sense had some diminution of sensation of the face varying from minimal involvement of the first and second divisions to complete bilateral anaesthesia The mechanism involved is apparently related to the toxic neuropathy which develops in the exposed areas of the face

Smith and Miller (1955) added sixteen cases treated by the same technique with fifteen excellent results and one fairly satisfactory These patients were all warned not to over expose themselves to sunlight The paraesthesia experienced consisted chiefly in formication more severe on the side of the face which had been affected by the neuralgia

Hydantoins The episodic nature of trigeminal neuralgia has suggested to some investigators a similarity to epilepsy and prompted a trial of hydantoin drugs in its treatment Bergouignan (1942) reported three cures with daily doses of 2 to 3 grams of a hydantoin drug all three patients experienced suborbital paraesthesia Lemoyne (1951) treated seventeen patients with dimethyldithiohydantoin and reported eight cures Jensen

and Zeh (1955) observed improvement in their patients with daily doses of 400 to 600 milligrams of chlorpromazine for three to four weeks the period of follow up was limited, however, being only two to nine months Cobaltchlorophyllin was employed by Pichler (1955) in eight cases with good results in four Two milligrams administered orally every day or every other day for a total of six to twenty doses were well tolerated The period of follow up is not stated

X ray Therapy The use of radiation in trigeminal neuralgia was reported by Gocht (1897) shortly after Roentgen s discovery A seventy six year old patient who had had severe right trigeminal neuralgia for ten years became sufficiently pain free after a two week course of therapy to dispense with the use of opiates The pain however recurred at a later date Another instance of temporary relief was reported by Gramegna (1905) Dariaux (1913) reviewed the results of x ray therapy in three patients and reported remissions of pain for only two to four months Wilms (1918) on the basis of twelve cases came to the conclusion that irradiation was a specific treatment and that alcohol injections should be reserved for those patients who did not respond He does not specify the duration of pain relief in his series but does report that three of the twelve failed to do well Langer (1932) recommended doses of 500 to 600 r directed toward the gasserian ganglion area Zimmern who in 1913 had postulated that radiation was effective only when the disease was due to inflammation of the nerve or its immediate surroundings came to a similar conclusion more than twenty years later (1935) when he declared x rays to be most beneficial when a clear organic cause can be found for the pain But there is of course no known organic cause for true trigeminal neuralgia

In twelve cases Dyke and Davidoff (1942) noted that improvement was incomplete and of short duration if not entirely lacking They stated however that they had not made a thorough trial of radiation therapy in view of the minimal risk and the ease with which posterior root section could be carried out even in elderly patients Burford (1950) recommended irradiation only if the patient refused surgical therapy or if this was not available

Surtees and Hughes (1954) also used B_{12} intramuscularly in doses up to 1 000 micrograms daily for ten days followed by the same dose twice a week for five weeks Considerable improvement or complete relief was experienced in fifteen cases the pain usually subsiding quite rapidly after the second or third injection Hammp (1955) however found that only two of four patients with true trigeminal neuralgia were helped by this medication in the same high dosage His patients were treated over a four to six week period

In our own experience while vitamin B_{12} may occasionally appear to hasten the disappearance of a mild attack we have never seen a full blown episode of trigeminal neuralgia relieved by its use

Vasodilator Drugs Vasodilator drugs such as nicotinic acid used by Cooper (1938) and betamethylcholine chloride by Adams and Robinson (1941) have been reported to afford temporary relief of trigeminal pain Amyl nitrite inhalation was said by Karl Peabody and Wolff (1945) to reduce the intensity and duration of the pain Histamine 10 per cent carbon dioxide and nicotinic acid were found by these authors to have a similar effect They postulate that the mechanism involved is a vaso dilatation of the blood vessels of the gasserian ganglion and adjacent sensory root small meningeal vessels have been seen to be dilated by nitrite when observed through a cranial window in animals

Miscellaneous Drugs Sporadic reports of the treatment of trigeminal neuralgia with a variety of other agents continue to appear in the literature Hermelink (1953) and Engelien (1954) employed Irgapyrin in a total of seventeen patients with five good results Hermelink however pointed out the danger of agranulocytosis with this as well as other Pyramidon drugs In three of his 671 cases treated for various complaints with Irgapyrin typical agranulocytosis developed with one death Decker (1955) reported on fifty patients treated with dihydroergotamine during 1948 and 1949 and followed until 1954 Forty two were improved with one or two courses of 6 milligrams daily for two to four weeks Most of these patients however had recurrence of pain within one year eight patients were not helped Seyffert (1955)

CHAPTER IX

ALCOHOL INJECTIONS INTO TRIGEMINAL DIVISIONS AND BRANCHES

Injection of alcohol into the divisions and branches of the trigeminal nerve is an effective albeit temporary method of providing relief from the excruciating pain of trigeminal neuralgia In most instances and especially when a trigger area can be included in the region rendered anaesthetic the patient will be free from pain as long as the loss of sensation persists At times in spite of good anaesthesia pain will not be abolished and in other instances relief will continue long after the anaesthesia has disappeared

History Alcohol was not the first substance to be injected in the hope of mitigating the pain of trigeminal neuralgia Bartholow (1876) described the use of chloroform instilled in the neighborhood of nerve trunks while Neuber (1883) used osmic acid in similar fashion Shortly thereafter Pitres and Vaillard (1887) demonstrated in animal experiments that both motor and sensory paralysis occurred following injection of alcohol directly into a nerve Histologic studies showed necrosis continuing for ten days succeeded by a quiescent period the degree of destruction varying with the strength of alcohol used About the fortieth day regeneration began to take place

Schloesser (1904) was the first to report the actual treatment of trigeminal neuralgia by the injection of alcohol into the peripheral branches of the nerve Ostwalt (1906) utilizing this method which he had observed in Schloesser's clinic in 1904 reported a fairly large series of cases Schloesser subsequently (1907) published his own results in 123 patients in whom various divisions of the nerve were injected by an intra oral approach

In summary Many investigators have sought a non surgical therapy for trigeminal neuralgia The very multiplicity of drugs and physical measures employed indicates that no effective remedy has been found An inherent defect in drug therapy is its bilateral effect in a condition which in 95 per cent of patients is unilateral this is particularly undesirable when the drug has a toxic or destructive action on nerve cells or fibers

of a destructive substance into the gasserian ganglion, producing necrosis of the ganglion cells should provide permanent relief The first attempts to obtain lasting relief of trigeminal neuralgia by such a procedure were made by Wright (1907) who introduced osmic acid into the gasserian ganglion following operative exposure The first suggestion of the possibility of injecting alcohol directly into the ganglion without a surgical incision was made by Harris (1909) In his early cadaver studies when practicing injections at the foramen ovale with an alcoholic solution of methylene blue he found that the gasserian ganglion was often stained by the dye If the needle advanced through the foramen ovale not only did color appear in the ganglion but the wall of the cavernous sinus and at times the ventral surface of the pons were also stained From this it was concluded that ganglion injection was feasible though a note of caution against rapid introduction of alcohol was sounded Harris s first gasserian ganglion injection with alcohol in an actual case of trigeminal neuralgia was carried out in November 1910, producing complete anaesthesia and pain relief which lasted until the patient s death twenty seven years later Harris (1912) employed the same route which he had used in injecting the third division and was soon able to report on seven patients treated over a period of fifteen months

Four months after Harris s report appeared Hartel (1912) described a method of injecting the ganglion with procaine which he employed in Bier s clinic in Berlin so that facial operations might be done without a general anaesthetic There is of course a vast difference between infiltration of the ganglion with procaine and the precise technique required for alcohol injection Subsequently in a very complete study Hartel (1914) detailed the currently accepted technique for alcohol injection of the gasserian ganglion The procedure was done entirely outside the oral cavity the skin being pierced anterior to the coronoid process Two or three attempts were often required before complete anaesthesia was achieved but in those instances where this was accomplished relief was lasting Hartel listed keratitis oculomotor palsies and facial weakness as complications encountered in the treatment of twenty four patients Camp (1914)

The more sterile external approach currently accepted was developed by Levy and Baudouin (1906).

Patrick (1907) and Hecht (1907) independently reported on the treatment of trigeminal neuralgia by alcohol block and were the first to use this method in the United States, their articles appearing in the same journal. By 1912 Patrick had given a total of 500 injections to 150 patients. In his experience relief after an effective block might last from six months to four years. As complications he listed oculomotor nerve paralysis, keratitis, necrosis of the soft and hard palate, and an occasional hematoma. In the meantime, Stewart (1909) had reported relief in 80 per cent of his patients for twelve months or longer.

Horrax and Poppen (1935) recommended alcohol injection in all patients prior to dorsal root section. Supraorbital and infraorbital as well as second and third division injections were made by these workers in 468 patients. Omitting the cases treated by supraorbital injection, the average period of relief was twelve months; in the supraorbital group it averaged six months. There were no serious complications in this large series.

Several additions to the basic technique of Levy and Baudouin have been suggested. Grant (1922) reported on a more exact method of infiltrating the second and third divisions with the aid of a special protractor called a "zygometer." On this device he worked out a series of angles in the vertical and horizontal planes through which the needle must pass to strike the second or third trigeminal divisions. Failure to reach the nerve trunk was thereby reduced as compared to other methods. In the ensuing years Grant's experience with this procedure has been extensive.

Silverstone (1955) utilizes a needle insulated to the tip, through which he passes an electric current; paraesthesias produced by 30 to 60 cycle square wave of 0.3 volts or less indicate that the tip is in contact with the nerve. When a higher voltage is required the needle needs readjustment. White and Sweet (1955) recommended a radiographic check on the position of the needle in all patients having a third division injection and in second division injections when these are attended by any difficulty.

Gasserian Ganglion Injections. While peripheral nerve blocks will afford temporary freedom from trigeminal pain, injection

Herpes was not an uncommon sequel and taste was lost unilaterally in 167 cases Keratitis hyperaesthesia to cold and post injection causalgia were also encountered Harris s outstanding success must be attributed in part to the caution implicit in his technique of injecting alcohol drop by drop and checking the resulting anaesthesia as the procedure progresses This method reduces the danger of widespread dispersal of the injected material

The main deterrent to the introduction of alcohol into the gasserian ganglion is the possibility of multiple cranial nerve palsies which may occur if the alcohol gains access to the free cerebrospinal fluid spaces at the base of the brain An anonymous case report appearing in the *British Journal of Surgery* in 1923 exemplifies this type of complication After an injection of alcohol into the right gasserian ganglion the right side of the head being uppermost the patient developed permanent left II III VI VII and VIII cranial nerve palsies There was also bilateral V and IX nerve dysfunction as well as a right sided keratitis with loss of vision In an attempt to prevent these complications Pollock and Potter (1916) suggested the use of fluoroscopy to check the position of the needle prior to carrying out a ganglion injection Their work based on a study of fourteen cadavers had not been tested in living subjects at that time Subsequently Putnam and Hampton (1936) and Kulenkampff (1942) reported on the use of x rays in patients to verify the position of the needle prior to injection

That ganglion block is still not commonly done is attested by the fact that fifty one of fifty two neurological surgeons polled by Jaeger (1957) stated they did not use ganglion injections of any type Jaeger himself sought to overcome the danger of spread of the injected material by substituting for alcohol a less noxious substance namely hot (80° C) water As a further safeguard he verifies the position of the needle roentgenologically His first patient was injected in 1953 Subsequently he reported that in 100 cases of true trigeminal neuralgia he had obtained relief of pain in ninety six There were no deaths facial weaknesses paralyses or corneal ulcerations though five patients had extraocular muscle weakness lasting from three to five months

originally reported favorably on ganglion injections but later in discussing a paper by Max Peet on dorsal root section (1918) stated that, in spite of his success he had abandoned the procedure having come to the conclusion that it was only a question of time until I should kill somebody by the injection and so I decided to leave the job to the surgeon

By 1940 Harris was able to publish an analysis of his results with alcohol injections of the peripheral division and the gasserian ganglion in 1,433 patients with trigeminal neuralgia In his skillful hands differential destruction of gasserian ganglion cells supplying various divisions was achieved Few can repeat this feat nor does it seem feasible to the surgeon as he sees the ganglion fully exposed at operation Harris s classic technique reported in 1926 may be quoted in part

> In 1921 I introduced and practiced a modification of the ganglion injection My method is to find the foramen ovale the usual way [extraoral approach] and anesthetize the third division with Novocaine so as to prove the position of the needle Then without using any alcohol I push my needle through the foramen for another quarter of an inch into the ganglion and then slowly drop by drop inject 90 per cent alcohol This is best done without any further preliminary Novocaine so as to avoid unnecessary swelling of the ganglion and gradually total trigeminal anesthesia results perhaps only after five drops of alcohol have been used The needle is then left in situ with the stilet inserted and a pause is made for five or ten minutes the patient keeping quite still Usually it will then be found that sensation is returning to the forehead and cheek *owing to the shock anesthesia of the ganglion cells passing off* A few more drops are then injected anesthesia again appearing and disappearing and again a pause is made as before It may be necessary to repeat this process four or five times before the anesthesia remains sufficiently deep and permanent and the operation may thus last an hour

Follow up studies in 451 cases in which the gasserian ganglion was injected showed freedom from pain for three years or more in 316 in the remainder a second or third injection was required before anaesthesia was permanent and lasting relief obtained seventy two having been followed from sixteen to thirty years

boiling distilled water is injected With the patient under very light anesthesia one can then demonstrate by pin prick an area of diminished sensation on the face corresponding to the well known anatomic destribution of the ganglion If 2 cc is injected into the fluid bearing area of the ganglion at one time the entire face will be almost completely anesthetized It has been found necessary to repeat the injection with increasing amounts of boiling water adding 0 5 cc to each injection until the desired anesthesia is produced As little as 0 5 cc of boiling water may stop the pain without producing extensive sensory loss

Under no circumstances should the needle be advanced beyond the petrous ridge which is approximately 20 millimeters beyond the edge of the foramen ovale If the foramen has been well entered and no fluid can be aspirated it is advisable to inject the water repeatedly in small amounts until the desired sensory loss is obtained beyond that observed in the distribution of the third division

Theoretically if injection of the gasserian ganglion can be adequately standardized it might become the treatment of choice for trigeminal neuralgia when all three divisions are affected It is doubtful however that a selective differential destruction of the ganglion can be accomplished with any degree of certainty when the pain is limited to a particular division Destroying the ganglion cells increases the danger of keratitis and may lead to other trophic changes This is in contrast to the relative absence of these sequelae after dorsal root section where the integrity of the ganglion cells is maintained

The period of freedom from pain following an effective alcohol injection varies being shortest when the supraorbital nerve and longest when the mandibular division is injected An inadvertent ganglion block in the course of a mandibular injection may account for the longer average duration of relief in this group Adson (1926) reviewed 839 cases seen at the Mayo Clinic in which a total of 2 338 injections had been made In the successful cases relief lasted nine to eighteen months Approximately 30 per cent of the injections however were incomplete either because the nerve could not be located or because scar tissue from previous blocks prevented its infiltration The results in several other large

The technique used by Jaeger (1955) follows closely that of Harris with the addition of the use of x rays to verify the position of the needle His method in part is as follows

> The procedure is carried out in the radiographic room under light pentothal anesthesia on a Franklin x ray stand After piercing the skin with a sharp pointed needle a 17 gauge 3 inch thin walled spinal puncture needle with a slightly dulled beveled point 4 millimeters in length is inserted through the skin of the cheek 3 centimeters below the malar bone and between the ramus of the mandible and the maxilla It is thrust toward the well known anatomic location of the foramen ovale until it engages the base of the skull—using due caution to move the point about slightly so as not to pierce through the foramen ovale unknowingly When the tip of the needle has been fixed in the periosteum its exact location is visualized by a roentgenogram showing the base of the skull Angling the tube slightly cephalad and lifting the mandible will facilitate clear visualization of the basal foramina When the needle tip can be clearly seen in relation to the foramen ovale it is moved the indicated distance in a direction so that it will enter this opening At this point the edges of the foramen can be palpated by the needle point and the sensation of entering the foramen is distinctly perceived There is almost invariably a jerk of the lower jaw from compression of the motor root as it comes through the foramen The precise location can be again verified by another roentgenogram From this point the needle is advanced 12 millimeters through the foramen and into the gasserian ganglion The measurement must be approximated by estimating the distance the needle is advanced from the malar bone as the shaft is held firmly by the left hand At some point between 12 and 17 millimeters from the foraminal edge blood tinged cerebrospinal fluid may be obtained by jugular compression or syringe aspiration This indicates that the needle tip has pierced the arachnoid reflexion surrounding the ganglion and sensory root of the fifth cranial nerve and that it has been properly placed in the ganglionic subarachnoid fluid bearing space (Meckel s cavity) for the injection As the needle is advanced its stylet is always kept in place to prevent obstruction of the lumen from small blood clots At the first sign of cerebrospinal fluid 0 5 cc of

Duration of Relief Following Alcohol Injection	Number of Patients
No relief	27—no anaesthesia
No relief	76—anaesthesia not recorded
Under 6 months	59
Under 1 year	44
Under 2 years	44
Under 4 years	24
TOTAL	274

Indications for Alcohol Injection In view of the gratifying results obtained by posterior root section and the success with which this procedure can be carried out on elderly and even poor risk patients the indications for alcohol injections in our opinion are relatively few Consequently we reserve injections for those individuals whose physical condition makes operation impossible—and in our experience this has been extremely rare—or for those who refuse surgical intervention Injection may serve as a temporizing procedure in a patient who is unable to submit to surgery at the moment We have also found that 500 cc of 10 per cent alcohol by slow intravenous drip is helpful in tiding a patient over a severe period of pain while already in the hospital awaiting surgery

Alcohol injections may be of assistance where the diagnosis is not clear cut failure to obtain relief of pain after a successful injection with good anaesthesia should make one discard the diagnosis of trigeminal neuralgia For diagnostic purposes the most peripheral branches which supply the required area are injected Third division blocks at the foramen ovale are to be avoided in any patient with the slightest suggestion of bilateral pain for fear of damage to the motor fibers Third division injection may also lead to inadvertent infiltration of alcohol into the ganglion with resultant scarring making subsequent differential section more difficult and sometimes impossible

Alcohol injection has had many proponents among men with vast experience in the treatment of trigeminal neuralgia This form of therapy is recommended not only for pain relief which is admittedly temporary but also in order to expose the patient to the

series of cases treated by alcohol injections show fairly consistent findings Combining the reports of Patrick (1912) Grant (1936) Horrax and Poppen (1935) Harris (1940) and Peet and Schneider (1952) the average duration of relief in more than 1 500 patients was as follows

Nerve Injected	*Length of Relief*
Supraorbital nerve	8½ months
Infraorbital nerve	12 months
Second division	12 months
Third division	[illegible] months
Ganglion	Permanent (several injections required)

As has already been stated freedom from pain outlasting the period of anaesthesia for many months or years may in some instances represent spontaneous remission of the disease rather than a persisting effect of the block Repetition of the injection rarely provides as long a period of relief as the first and is seldom justified Gasserian ganglion injections are technically more difficult and more hazardous than peripheral injections but offer the possibility of long term or even permanent respite from pain

In view of the hazards of ganglion injections and since injections by other routes afford at best only temporary relief we have restricted this measure to an occasional instance where the diagnosis was in doubt where temporary relief was imperative before operation could be performed or where the patient refused surgery

Two hundred and seventy four or somewhat over one third of our patients had had at least one alcohol injection either at the Neurological Institute or elsewhere before being seen by us Twenty seven obtained neither anaesthesia nor relief in seventy six additional patients the presence or absence of anaesthesia was not recorded but they were known to have experienced no relief In the remaining cases relief lasted under six months in fifty nine between six months and one year in forty four between one and two years in forty four and from two to four years in twenty four A number of these patients had received multiple blocks sometimes as many as nine or ten before being seen by us with varying periods of relief usually with decreasing effectiveness

numbness postoperatively has been overemphasized We are in agreement with this view

Technique Familiarity with head and neck dissection practice of injection with colored solutions and instructions by those experienced in this field are prerequisites to alcohol injection Until the three dimensional anatomical relationship is thoroughly visualized it may be helpful to have a skull close at hand while the procedure is being carried out

A successful alcohol block of the trigeminal divisions requires cooperation on the part of the patient as his recognition of sudden pain along the course of the nerve is the most accurate indication that it has been transfixed by the needle He should therefore clearly understand the distribution of the pain which will be experienced when the needle is in the nerve and be able to inform the operator of its appearance by some prearranged signal such as raising his hand (without speaking or moving the head) A mild sedative or analgesic may be administered prior to the block though usually this is not necessary If alcohol injection is to be satisfactory the needle must *enter* the nerve Injection of alcohol in the *region* of the nerve not only will not relieve pain but may damage neighboring structures If the patient is uncooperative or if the nerve cannot be transfixed the procedure should be discontinued in favor of another trial at a later date or of posterior root section

If the second and third divisions are involved each can be injected at the same session More commonly however the pain and trigger areas are primarily in one division with overflow into an adjacent division If the region primarily affected is anesthetized by an injection the overflow pain is usually controlled

The equipment for an injection includes two 5 cc Luer Lok syringes one for the introduction of procaine into the skin (and nerve if desired) and one to be used only for the final injection of absolute alcohol There are also provided two 3 5 cm 26 gauge needles to be used for skin infiltration and for supra and infra orbital injections two short beveled 22 gauge lumbar puncture needles a centimeter ruler and several short segments of No 12 rubber catheter to serve as markers on the needle to limit

type of sensory change which will become permanent after dorsal root section Cushing (1920), for example expressed the opinion that a previous alcohol injection serves to help the patient adjust to the sensory changes which follow dorsal root section and make dysaesthesias less annoying This would appear to be questionable according to our statistics

In order to clarify the relationship of preoperative alcohol injections to postoperative paraesthesiae, a group of patients treated by members of the Attending and Resident Staff of the Neurological Institute were interrogated by interview and questionnaire Responses were obtained from 250 One hundred and thirty nine stated that they were completely accustomed to the numbness which followed posterior root section Seventy four or 53 per cent had had alcohol injections, and sixty five or 47 per cent had not been injected Of seventy six patients who were mildly annoyed by the numbness, thirty three or 43 per cent had been injected while forty three or 57 per cent had not Of the thirty five patients who were extremely annoyed by the numbness sixteen or 46 per cent had had an injection while nineteen or 54 per cent had not

Tolerance of Anaesthesia	*Number of Patients*	*Per Cent Injected*	*Per Cent Not Injected*
Accustomed	139	53 per cent	47 per cent
Mildly annoyed	76	43 per cent	57 per cent
Severely annoyed	35	46 per cent	54 per cent

These figures would suggest that preoperative alcohol injections had relatively little effect on ability to adjust to the postoperative anaesthesia and that for this purpose they are of doubtful value *It is also of interest that 95 5 per cent of those* patients in our study who had had both alcohol injection and posterior root section preferred the surgical procedure Peet and Echols (1946) did not recognize the need of teaching the patient how anaesthesia of the face feels as an indication for a block and Peet and Schneider (1952) on the basis of their experience concluded that the importance of preoperative injection with alcohol to determine whether the patient will complain of

Infraorbital Injection The infraorbital nerve, terminal branch of the maxillary nerve leaves the skull through the infraorbital foramen to supply the lower eyelid the skin of the side of the nose the anterior portion of the skin of the cheek and the mucous membrane of the upper lip It does not supply the mucous membrane of the palate or upper gum This nerve is most frequently blocked when a trigger area is present in the naso labial fold a fairly common location The infraorbital foramen can be palpated about 1 cm below the midpoint of the lower margin of the orbit The technique of injection is the same as for the supraorbital injection The canal runs laterally and upwards so that the needle should be inserted into the skin about 1 cm below and slightly medial to the foramen A long hypodermic needle can be threaded at least 1 cm into the canal at which point aspiration with the syringe should be attempted if air is obtained it indicates that the antrum has been entered and that alcohol injection is unsafe No more than 1 0 cc of alcohol should be introduced drop by drop The point of the needle should be moved several times to insure destruction of all fibers

Injection of the Maxillary Division The maxillary nerve passes through the foramen rotundum to traverse the sphenomaxillary fossa where some branches are given off before it enters the orbital cavity through the sphenomaxillary fissure When alcohol is successfully injected into this division anaesthesia is obtained on the cheek side of the nose upper lip upper gum and palate The nerve is injected as it leaves the foramen rotundum in the maxillary fossa

The injection is made with the patient supine on a stretcher or table with the head turned so that the affected side is uppermost and the sagittal plane of the skull is parallel to the floor Some operators prefer to have the patient seated squarely in an erect position with the side of the face to be injected towards the operator A nurse or assistant supports the patient s head against her body to prevent his withdrawing from the needle No matter what position is utilized it is most important to have the patient oriented in relation to the room in order to estimate as accurately as possible the angle of insertion of the needle

The site of entrance of the needle for injection of the maxillary

the depth of insertion of the lumbar puncture needles if the latter are not marked in centimeters Absolute alcohol obtained in 2 cc vials is used for the injection

The skin in the region to be injected is sponged with tincture of Zephiran or alcohol solution and the bony landmarks are palpated through a 2 x 2 cm square of gauze dampened with the same solution Sterile gloves may be worn to carry out these injections but caution must be exercised to avoid contamination of the needles and syringes as only a small part of the field is sterile

When the nerve to be injected has been successfully penetrated some prefer to inject a small amount of procaine (less than 1 cc) prior to the introduction of the alcohol With the needle in the nerve trunk some force will be required for the injection and the resultant anaesthesia will serve as a preliminary check on the position of the needle This procedure however has the disadvantage of diluting the absolute alcohol thereby reducing its destructive effect hence we prefer to omit this step when possible The pain produced by the direct injection of alcohol rarely lasts longer than a few seconds and is of no greater magnitude than a spontaneous attack of trigeminal neuralgia

The four injections we most commonly use are second division third division infraorbital and supraorbital nerves

Supraorbital Injections The supraorbital nerve supplies the frontal sinus the upper eyelid and the trigger areas in the scalp or eyebrow This nerve leaves the orbit through the supraorbital notch or foramen usually felt at about the junction of the inner and middle third of the eyebrow Occasionally the notch is extremely shallow or the foramen may be on the under surface of the orbital rim but nevertheless accessible or the nerve may exit from the skull in several smaller twigs

After sterilization of the overlying skin through a small wheal of procaine another needle is gently threaded as far into the notch or foramen as possible Not more than 0 5 cc of absolute alcohol is injected drop by drop Considerable edema will ensue if alcohol is allowed to escape into the periorbital tissues In some patients in whom the nerve has divided before reaching the supraorbital rim a satisfactory injection is difficult Supraorbital avulsion might better be considered in these patients

into the area just below the sigmoid notch Through the wheal thus produced a 22 gauge short beveled lumbar puncture needle with a rubber check previously threaded to a point 5 5 cm from the tip is inserted The needle is directed approximately 115 degrees upward to the sagittal plane of the skull and angled slightly forward *i e*, towards the nose also at an angle of approximately 115 degrees striking the pterygoid plate at a depth of about 4 5 cm The point is then withdrawn and angled further forward, a little at a time until it passes off the plate to enter the sphenomaxillary fossa If the needle is then inserted 5 5 to [illegible] cm it will pierce the maxillary division and the patient will immediately experience pain and paraesthesias in the distribution of the nerve If the needle is angled too far forward and upward it may damage the third fourth and sixth cranial nerves and the ophthalmic division as they pass through the superior orbital fissure With insertion at the correct angle but at too great a depth the nasal cavity may be punctured To avoid these complications and as a final check on the position of the needle a trial injection of a small amount of procaine can be made before instilling the alcohol Once the needle point is known to be within the nerve 1 to 1 5 cc of absolute alcohol is slowly injected drop by drop As pointed out above the use of procaine prior to the injection of alcohol diminishes the effectiveness of the block and should be omitted if possible

Injection of the Mandibular Division The mandibular nerve is the most lateral division of the gasserian ganglion leaving the skull through the foramen ovale at which point it is joined by the motor root of the trigeminal nerve This relationship is of the utmost importance when treating a patient who is suspected of having bilateral trigeminal neuralgia and in whom bilateral damage of the motor roots must at all costs be avoided The calamitous nature of bilateral motor root paralysis will be obvious when one realizes that this division innervates all the muscles of mastication *i e* temporal masseter external and internal pterygoids and buccinator as well as the anterior belly of the digastric, the mylohoid the tensor palati and the tensor tympani muscles Recovery from this type of motor paralysis usually takes several months and may never be complete After the emergence of the

division is just below the middle point of the zygomatic arch, a point corresponding to the sigmoid notch. This is located by placing the index finger in front of the tragus and asking the patient to open and close his mouth. The condyle of the mandible will be felt to move under the finger, which is then placed anterior to the condyle and held at right angles to the arch. When the patient again opens and closes his mouth, a de-

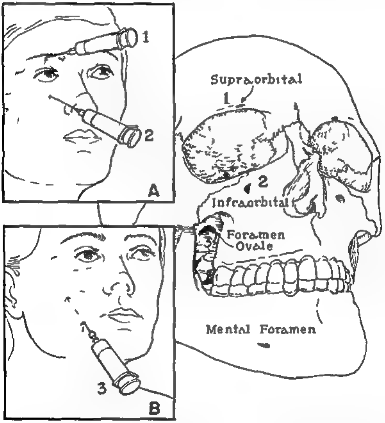

Fig. 44. Diagrammatic representation of alcohol injection. A. 1. Needle in place for supraorbital injection. 2. Needle in place for infraorbital injection. B. 3. Needle in place for gasserian ganglion injection.

pression is felt in which the finger lies. This depression is the sigmoid notch. For both the mandibular and maxillary injections the needle is introduced just below this point; it is located about 2.5 cm. anterior to the tragus of the ear on a line drawn from the tragus to the nasolabial fold.

The skin is sterilized and 1 per cent procaine is injected

into the area just below the sigmoid notch Through the wheal thus produced a 22 gauge short beveled lumbar puncture needle, with a rubber check previously threaded to a point 5 5 cm from the tip is inserted The needle is directed approximately 115 degrees upward to the sagittal plane of the skull and angled slightly forward, *i e*, towards the nose also at an angle of approximately 115 degrees striking the pterygoid plate at a depth of about 4 5 cm The point is then withdrawn and angled further forward a little at a time until it passes off the plate to enter the sphenomaxillary fossa If the needle is then inserted 5 5 to 6 cm it will pierce the maxillary division and the patient will immediately experience pain and paraesthesias in the distribution of the nerve If the needle is angled too far forward and upward it may damage the third fourth and sixth cranial nerves and the ophthalmic division as they pass through the superior orbital fissure With insertion at the correct angle but at too great a depth the nasal cavity may be punctured To avoid these complications and as a final check on the position of the needle a trial injection of a small amount of procaine can be made before instilling the alcohol Once the needle point is known to be within the nerve 1 to 1 5 cc of absolute alcohol is slowly injected drop by drop As pointed out above the use of procaine prior to the injection of alcohol diminishes the effectiveness of the block and should be omitted if possible

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mandibular nerve through the foramen ovale it continues as a single trunk for only 2 to 3 mm before dividing into its various branches The nerve must therefore be injected just as it leaves the skull *if satisfactory relief of third division pain is to be* achieved This division carries sensation from part of the auricle of the ear the external auditory meatus the lower portion of the cheek the lower lip the mucous membrane of the mouth the tongue the lower teeth and gum

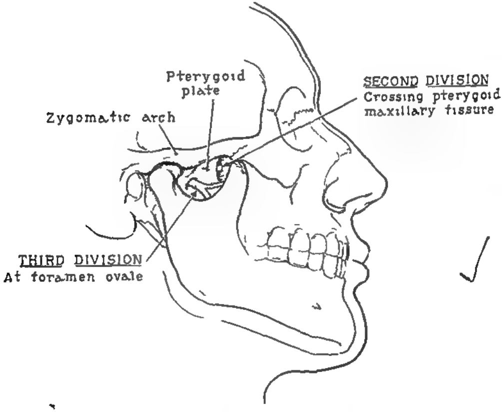

Fig 45 Diagrammatic sketch demonstrating bony landmarks involved in injection of both second and third divisons

In point of technique this injection is identical in all respects to that of the maxillary division except that while the needle is inserted at a 115° angle to the sagittal plane of the skull it is *directed straight inward rather than slightly forward* The needle point passes therefore just behind the pterygoid plate where it will reach the mandibular nerve at a depth of 4 5 to 5 cm below the skin surface The three hazards in carrying out this

injection are puncture of the eustachian tube laceration of the middle meningeal artery as it enters the foramen spinosum and passage through and beyond the foramen ovale to the ganglion Pain in the ear usually indicates that the eustachian tube has been pierced while pain in the temple suggests irritation of the middle meningeal artery Inadvertent ganglion block with the added risk of alcohol escaping into the free spinal fluid spaces is more likely to occur in edentulous individuals Pain in the distribution of the first or second divisions on insertion of the needle should warn the operator that he has

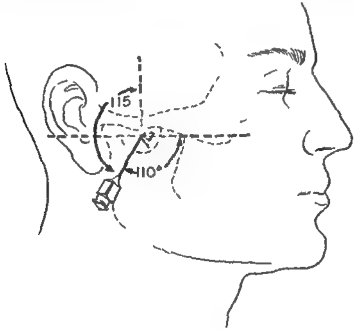

Fig 16 Diagrammatic representation of needle inserted for second division injection Note horizontal and verticle angles of insertion

probably entered the ganglion At this point he may choose to inject alcohol drop by drop in an attempt to give more permanent relief by ganglion block or he may choose to withdraw his needle until it rests solely within the third division and inject this division alone If the needle is not inserted deeper than 5 cm if aspiration for blood and cerebrospinal fluid is negative and if pain is experienced in the third division only the *injection* can be carried out with alcohol alone omitting preliminary use of procaine One to 1 5 cc of absolute alcohol is slowly injected drop by drop

It will be noted in the above descriptions that the same entrance point in the skin is recommended for both the second and third division injections In the experience of one of the authors (J R) this simplifies the number of angles and measurements to be learned and has yielded satisfactory results Labat (1922) has also pointed out the possibility of injecting both the maxillary and mandibular nerves from a single point of entrance The more classical technique based on the method developed by Levy and Baudouin is to use the point described for the penetration of the skin for injection of the third division but to move 1 cm forward for injection of the second division The needle in the latter case is then advanced in a forward and upward direction at an angle of 110 to 115 degrees with both the vertical and horizontal axes of the skull When the pterygoid plate is encountered usually at a depth of about 5 cm the needle is angled further forward until it slips over the edge of the plate into the pterygomaxillary fissure The second division lies at a depth of 0 5 cm in this fissure As can be seen there are only minor differences between these techniques

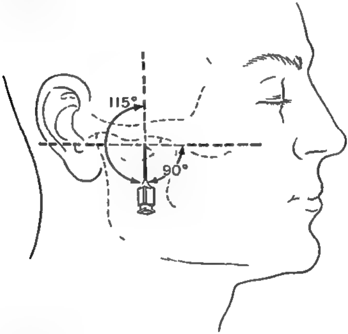

Fig 47 Diagrammatic representation of needle inserted for third division injection Note horizontal and verticle angles of insertion

After becoming proficient in carrying out injections, one may vary the site of insertion of the needle slightly dependent on the nerve to be injected and the shape of the patient's skull. Alcohol injection into the divisions and branches of the trigeminal nerve is based on the ability to visualize the three dimensional anatomy involved. Once the surgeon has mastered the procedure the need to follow "cook book" instructions is obviated. The instantaneous sharp pain in the area supplied by the division to be injected when the desired nerve is entered remains the most dependable indication of the position of the needle.

Electrocoagulation. In lieu of injection of a destructive material Kirschner (1931 and 1933) suggested electrocoagulation of the gasserian ganglion. A needle insulated except at its tip was inserted through the foramen ovale with the aid of a special frame attached to the head. Relief was thus achieved in 96 per cent of 250 patients (1936). Over a five year period there was a recurrence of pain in 25 per cent but recoagulation was easily performed. Zenker (1938) working in Kirschner's clinic had four deaths in 500 cases of electrocoagulation. Kubanyi (1946) published his results obtained after coagulation of the ganglion in 460 cases. There were two deaths in his series. Twenty eight per cent of his patients had a recurrence of pain; in thirteen keratitis developed and two eventually lost an eye. Ruland (1953) reported good results with electrocoagulation as a technique for peripheral trigeminal blocks. Grant (1936) utilized electrocoagulation of the infraorbital nerve after operative exposure and avulsion of this branch under direct vision as a method of producing more complete destruction.

It will be noted in the above descriptions that the same entrance point in the skin is recommended for both the second and third division injections In the experience of one of the authors (J R) this simplifies the number of angles and measurements to be learned and has yielded satisfactory results Labat (1922) has also pointed out the possibility of injecting both the maxillary and mandibular nerves from a single point of entrance The more classical technique based on the method developed by Levy and Baudouin is to use the point described for the pene-

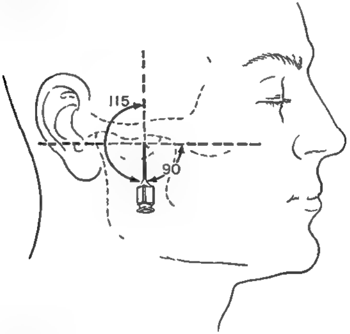

Fig 47 Diagrammatic representation of needle inserted for third division injection Note horizontal and verticle angles of insertion

tration of the skin for injection of the third division but to move 1 cm forward for injection of the second division The needle in the latter case is then advanced in a forward and upward direction at an angle of 110 to 115 degrees with both the vertical and horizontal axes of the skull When the pterygoid plate is encountered usually at a depth of about 5 cm the needle is angled further forward until it slips over the edge of the plate into the pterygomaxillary fissure The second division lies at a depth of 0 5 cm in this fissure As can be seen there are only minor differences between these techniques

name of the surgeon the date of performance, sex and age of the patient duration of the disease length of the segment removed and other pertinent details Reviewing the facts thus assembled Fowler concluded that the results of neurectomy although they do not bear out the brilliant anticipations once held yet are such as to give surgeons quite as much confidence in this as in other operations when but a remote hope of cure can be held out and which must be necessarily but palliative in the large majority of cases In this sense alone neurectomy in properly selected cases is not only justified but most imperatively demanded

Fowler's critical study stimulated further efforts at solution of the problem Because of the dubious results of section of the divisions of the trigeminal either intracranially or extracranially another procedure was evolved Working independently Rose of London (1890) and Andrews of Chicago (1891) developed an operation which Rose was the first to perform This consisted in section of the zygoma and coracoid processes and detachment of the masseter and temporal muscles to expose the base of the skull and the foramen ovale Trephining was then done to expose the gasserian ganglion and the second and third divisions were sectioned The ganglionic tissue, which is exceedingly soft could then be pulled away piecemeal with curved hooks or as Andrews suggested curetted The dangers inherent in this procedure in which the ganglion could not be adequately visualized did not commend it as a satisfactory method

Palliative Surgical Procedures

The value of peripheral sections in selected cases particularly those patients in a debilitated state has again been rightly emphasized by Grantham and Segerberg (1952) In their series the average duration of relief was 33 2 months with a range from five months to eight years The longest period of relief from supraorbital avulsion we have had has been six years and for the infraorbital two years The relief is usually longer than can be gained by alcohol injection and avoids the harrowing experiences which so frequently accompany the latter procedure The value of this palliative method should not be lost to the arma

CHAPTER X

TRIGEMINAL PERIPHERAL NEURECTOMY

Some of the earliest work in neurosurgery was directed toward relief of the excruciating pain of trigeminal neuralgia The initial attempts as has previously been stated consisted in peripheral section of the trigeminal divisions

Among the American pioneers in this field was Carnochan (1856) Professor of Neurosurgery in New York Medical College In accordance with his belief that the real seat of the disease lay in the trunk of the nerve and that no operation could rationally lead to a successful result unless all the branches extending from it were cut off from communication with the brain he directed his attack to Meckel's ganglion through the maxillary sinus This ganglion composed of gray matter he describes as a generator of nervous power of which like a galvanic battery it affords a continuous supply while the branches of the ganglion under the influence of the diseased trunk serve as conductors of the accumulated nervous sensibility In his report appearing in 1858 he describes three cases in which the ganglion was removed with an inch or more of the second division of the trigeminal nerve

In the next three decades numerous peripheral sections were reported by J R Wood (1866) R Fowler (1886) and others and several collected series appeared in the literature In Germany Wagner (1869) published an exhaustive review of neurectomy for relief of neuralgia of the fifth cranial nerve ten years later Dennis (1879) collected and tabulated neurectomies involving the second division together with removal of the sphenopalatine ganglion according to the method of Carnochan and in 1886 Fowler presented details of eighty three operations (mostly performed after the appearance of Wagner's series) including the

CHAPTER XI

HISTORICAL BACKGROUND OF TRIGEMINAL DORSAL ROOT SECTION

Holding as I do this opinion, I believe that operative procedure in these cases is an imperative duty when all medical measures of relief have failed.

— SIR VICTOR HORSLEY

The inadequacy of these early procedures and a better understanding of neuroanatomy led inevitably to a more fundamental approach to the problem. In 1891 Horsley, Taylor and Coleman published an account in the *British Medical Journal* of an exposure of the gasserian ganglion through the temporal bone. By opening the dura and retracting the temporal sphenoidal lobe they were able to bring the ganglion and dorsal root into view and to avulse the root, thus laying the foundation for the future development of trigeminal dorsal root section.

A year after Horsley's operation, Frank Hartley (1892) of New York proposed the procedure which in its essentials is still used for exposure of the gasserian ganglion. He made a small omega-shaped incision just above the zygoma and turned down a flap including the skin, muscle and bone, exposing the ganglion by an *extradural* approach. The nerves were divided at the foramen ovale and rotundum, and the part between them and a point beyond the gasserian ganglion was excised. Hartley's first operation was done on August 15, 1891; it was presented before the New York Surgical Society on January 13, 1892, and was first published in the *New York Medical Journal*, March 1 of the same year, followed by additional cases in 1893. On February 23, 1892, six and a half months after Hartley's operation, Fedor Krause independently employed a similar approach, presenting his case before the Deutsche Gesellschaft fur Chirurgie

mentarium of the neurosurgeon since it is so simple carries with it no complications and the relief albeit temporary is certain

Supraorbital and Infraorbital Neurectomy

Only minor technical points need be emphasized The incision for the supraorbital nerve should be made *within* the eyebrow without shaving since occasionally the hair if shaven may grow back a shade lighter or darker and a relatively long time is required for regrowth Another technical point trivial though important is the use of forceps with rounded jaws to grasp the nerve, so that as it is twisted around the forceps it will not be cut by a sharp edge A second forceps is applied after a small part of the nerve has been withdrawn so as to obtain a fresh hold and twisting is again continued In this manner a longer segment can be obtained and the nerve can thus be torn as close to the ganglion as possible The nearer the ganglion the greater the damage to the ganglion cells The duration of relief is dependent primarily on the degree of central chromatolysis of the ganglion cells and the number of cells destroyed For this reason as much of the nerve should be avulsed as possible

In order to avoid a visible scar the infraorbital nerve is exposed intraorally *Section of the infraorbital is made intraorally* by carrying the incision through the mucous membrane at the apex where it is reflected upon the maxilla about 1 5 cm above the alveolar border The periosteum is elevated and the infraorbital nerve is easily identified as it emerges through the infraorbital foramen in line with the upper canine

After the nerve has been avulsed the severed end can be cauterized by passing a small wire within the foramen and touching the wire with the cautery The incision in the mucous membrane is closed with fine catgut

Fig 48 Sir Victor Horsley Courtesy New York Academy of Medicine Sir Victor Horsley in 1891 was the first deliberately to sever the trigeminal dorsal root for trigeminal neuralgia

A broad copper retractor with smooth and everted edges is then gently slipped underneath the lobe and slowly but steadily raised The lobe is partly molded partly lifted upwards and the floor of the skull is then easily seen and illuminated with the electric light The guide to the fifth nerve is the upper border of the petrous bone The lobe being raised a little more the edge of the tentorium will be defined and the point at which the fifth nerve passes beneath it could in the first case operated upon be seen The position of the canal in which the nerve is lying just above the ganglion must then be estimated and a small puncturing incision made into it As it is about a quarter of an inch in diameter it can be recognized as soon as the puncturing instrument passes into it and the dura forming its roof should then be slit open The nerve in this way is exposed and is found to be freely lying

June 10 1892 and describing it in the *Archiv fur klinische Chirurgie* the following October 11 The procedure, at the suggestion of Horsley came to be known as the Hartley Krause method but priority in its use clearly belongs to Hartley whose operation and publication antedated those of his European contemporary

Cushing (1900) referred to his approach as differing only in details from that devised by Hartley In order to avoid bleeding from the middle meningeal artery Cushing suggested going sufficiently low so as to work beneath the middle meningeal as it passes along the surface of the dura—a trivial modification and of little consequence in view of the variable course of the middle meningeal artery on the surface of the dura

With this general background for the evolution of the operation of trigeminal dorsal root section it may be well to review in fuller detail some historical aspects the significance of which has unfortunately been obscured Horsley s fundamental concept has never been accorded the credit it is due It seems fitting therefore that his account of the first trigeminal dorsal root section to be deliberately planned and carried out should again be presented

Attempts to strip off the ganglion along its upper half and near the cavernous sinus almost invariably resulted in tearing of the sinus For this reason Horsley concluded that complete removal of the gasserian ganglion was not practicable Finding this to be the case he writes I then considered the possibility of dividing the fifth nerve behind the ganglion Having tried this operation on the monkey and also on the cadaver he undertook it on a patient with recurrent pain referable to the second and third trigeminal divisions following earlier peripheral sections

Referring to the operation some years later Horsley mentions the name of Macewen stating that independently they had done a trigeminal dorsal root section dividing the dorsal root and thus making sure to cut off all possible paths between ganglion cells and the central apparatus of the nerve Macewen failed to publish his work but Horsley s operation was reported in detail December 12 1891 In this account he refers to his method of exposing the temporo sphenoidal lobe and the trigeminal dorsal root as follows

Van Gehuchten (1903) in referring to Horsley s operation, erroneously says that Horsley had intended to remove the ganglion but was forced to avulse the root not as an operation of choice but because of uncontrollable bleeding Tiffany (1893) however gives full credit to Horsley and says of the operation while the result was not favourable both conception and execution thereof were worthy of their distinguished author Ferrier (1890) had given expression to a similar concept some years earlier when he proposed in a discussion of Rose s operation on the gasserian ganglion that the section of the nerve above the ganglion might cause ascending degeneration and thus lead to relief by producing atrophy of the centers Van Gehuchten believed that the same physiological extirpation could be accomplished by sudden forcible avulsion of the peripheral division which would be followed within twenty five to thirty five days by destruction of the ganglion cells

The next reference to dorsal root section is made by Spiller seven years after Horsley s operation in a paper by Keen and Spiller (1898) In subsequent publications Spiller has himself frequently referred to his statement and it has served as a basis for crediting him—erroneously—with priority in the concept of the operation His pathological report on seven ganglia removed by Keen concludes with the following statement If it could be shown that the sensory root of the gasserian ganglion does not unite after its fibers are divided we should have a fact of great importance Division of this root would probably be a less serious operation than removal of the entire ganglion and might have the same effect in the relief of pain but the surgical difficulties might be insurmountable Experiments on animals to determine whether or not the sensory root of the gasserian ganglion unites after section of the fibers might result in a lessening of the great mortality now existing in operations on the ganglion In essence the idea here expressed does not differ from that of Ferrier or from the concept inherent in Horsley s operation except for the proposal to establish *experimentally* whether or not regeneration of the sensory root takes place Actually Spiller s statement raises doubt as to both the advisability and feasibility of the procedure

> in the little passage Since the recurrent pain invaded apparently the stump of the second division I thought it best to attempt the operation of dividing the nerve behind he ganglion The patient had not eaten any food for several months and was not in a good condition to undergo the operation However as her state was a desperate one, I agreed to perform the operation warning her friends that there might be fatal collapse even on the table As a matter of fact the operation presented no special difficulty beyond that of a very tedious nature I resected the zygoma in order to have more room but I feel sure now that that was a useless complication—that it was quite possible to have reached the nerve without it and I regret having done it because I think it of course aided in producing the shock which caused a fatal termination to the case On exposing the nerve in the canal behind the ganglion, I passed a small blunt hook around it, and it then occurred to me that the small branch of the basilar artery which accompanies the nerve might give some trouble I there fore thought one might safely attempt avulsion of the nerve from the attachment to the pons and on gently drawing on it with a hook this was easily accomplished

Unfortunately the patient died Horsley attributed her death to shock

> I found there was no cause of death except that already mentioned *i e* shock There had been a slight amount of oozing into the subarachnoid space but nothing to produce any compression at all and of course of that there were no symptoms during life At the moment when the fifth nerve was separated from the pons although the patient was well under the anaesthetic there was arrest of respiration and the pulse could not be felt This lasted for probably not more than three to four seconds and then the respiratory move ments and the pulse became normal On reviewing the result of this operation I am satisfied that the unfavourable termina tion was due to the special circumstances of the case and the considerable series of experiments on the lower animals which have been made involving the division of the fifth nerve show clearly that the mere exposure and section of the nerve is not of itself dangerous to life

avulsing the central end without removal of the ganglion as when the ganglion itself is excised

Following this definite and forthright statement by Barker Spiller and Frazier (1901)* operated on dogs Of these experiments Spiller wrote

> Frazier has cut the sensory root of the trigeminal nerve in a large number of dogs Seven of these lived long enough for *a study of the nervous system by the Marchi method* [The italics are the author s] The results of my microscopic examinations of the nervous system from these seven dogs is as follows Two of the dogs numbers 4 and 5 were especially satisfactory for microscopic examinations while the others presented too little degeneration to permit of valuable conclusions being drawn In dogs 4 and 5 it is evident that the lateral portion of the extracerebral sensory root of the trigeminal nerve was cut while the median portion was not cut

Even the two dogs which were especially satisfactory for microscopic examinations cannot be said however to afford *any* histologic evidence as to regeneration of the sensory root since for Marchi stains to be useful the animals must be sacrificed within a short period Furthermore only two of the large number of dogs showed satisfactory degeneration and in these two the dorsal root had ben only *partially* cut Thus it was not shown experimentally by Spiller and Frazier that the sensory root of the gasserian ganglion fails to unite after its fibers are divided Consequently Spiller turned to the literature saying and with this object in view an examination of the literature is desirable On this basis though no evidence was brought forth that the trigeminal dorsal root did not regenerate Spiller concluded that because of the great mortality in removal of the ganglion dorsal root section was desirable

While there is no idea of withholding from Spiller and Frazier the credit that belongs to them for their valuable contributions to the field of trigeminal surgery it has seemed desirable here to place in proper chronological sequence the steps in the establishment of trigeminal dorsal root section that it may be viewed

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* Frazier June 1901 stated I began some 15 months ago with Dr Spiller operation on dogs i e after the Philadelphia symposium had been held

In Aprıl 1900 a symposıum on The Fifth Nerve ın Its Neurologıcal and Surgıcal Relatıons was held ın the College of Physıcıans Phıladelphıa at whıch Keen and Spıller Cushıng Davıs Barker, Abbe and Dana presented papers No reference by Spıller ıs found ın thıs symposıum to any experımental work nor ındeed to any dorsal root sectıons Barker however ın hıs presentatıon *made the unequıvocal statement that ın tıc doulou* reux due to dısease of the perıpheral set of trıgemınal sensory neurons relıef should be as complete and permanent by cuttıng the nervus trıgemınus between the ganglıon and the pons and

Fıg 49 Frank Hartley Courtesy New York Academy of Medıcıne Frank Hartley ın 1892 was the fırst to develop the extradural approach to the gasserıan ganglıon

the recognition it merits Later when Frazier (1925) proposed what he termed subtotal section and by subtotal section is implied section of only those fasciculi which supply the outer two thirds of the ganglion no reference was made to Tiffany's basic idea of doing a subtotal removal in order to save the sensitivity of the cornea

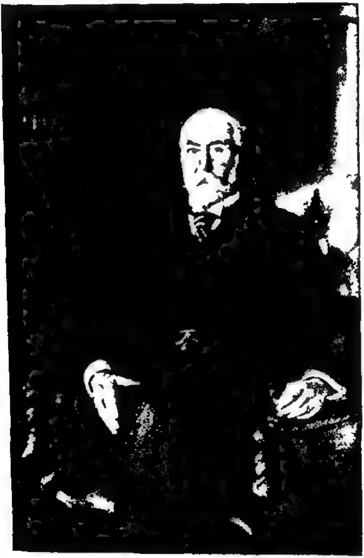

Fig 50 Louis McLane Tiffany Photograph of portrait Courtesy William S Stone Dean University of Maryland School of Medicine Louis McLane Tiffany in 1896 was the first to propose saving the ophthalmic fibers in order to protect the cornea and in 1896 the first to advise sparing the motor root

against its true historical background Actually, Spiller's tentative suggestion was antedated eight years by Ferrier's opinion quoted above and was framed in more positive terms by Barker at the Philadelphia Symposium which has been cited Frazier's reference (1901) to this plan of operation so radically different, suggested to me by William G Spiller fails to take into account the fact that Horsley had deliberately cut the trigeminal dorsal root ten years earlier *The only real difference between the two* procedures lay in the fact that Frazier, operating on October 12 1901 used Hartley's extradural approach which with the strides in neurologic surgery in the intervening period had become established as the standard route for exposure of the gasserian *ganglion The fundamental concept was identical*

The further refinements of trigeminal dorsal root section are of equal historic significance To Tiffany of Baltimore we are indebted for two major developments—subtotal resection and preservation of the motor root The first suggestion for subtotal *resection was made by Tiffany in 1896*

> It may be accepted he wrote without hesitation that the ganglion and branches can be removed after being clearly exposed I doubt the expediency of so doing 1 The first branch is never affected alone it may be involved reflexly 2 Trouble of one kind or another has often been met with when the first division is removed Involvement of the eye shows itself as anaesthesia of the cornea requiring protection for a long time panophthalmitis etc These are the two main reasons why it is well not to take away the upper portion of the ganglion and first branch but rather to remove the second and third branches with the corresponding portion of the ganglion

In a paper by Keen and Spiller two years later (1898) Keen refers at length to Tiffany's suggestion that only the outer two thirds of the ganglion together with the second and third divisions should be removed and the inner third left Since the only object in leaving the inner third is the consideration of vision Keen felt that this was an unnecessary refinement and that any difficulty with the eye could be handled

Tiffany's valuable and fundamental concept has not received

In Keen and Spiller's paper (1898), Keen refers to Tiffany's suggestion saying Tiffany has expressed the opinion (1) that the motor root can be saved and (2), that it ought to be saved Keen felt that the only possible absolute necessity for preserving the motor root would be the need for preserving it in case of bilateral ganglion resection This has never yet been necessary and will surely be extremely rare

More than twenty years later the problem of the motor root was still a live one In 1921, Frazier stated A year ago I took up this motor root problem and found a solution [In a footnote he credits Dr C C Coleman with suggesting to him the use of the electrode during the war] In the past the motor root was often sacrificed because the surgeon was afraid he might be leaving a fasciculus of the sensory root with all its unfortunate possibilities But with the use of the electrode the motor root when exposed can positively be identified as motor by observing the temporal muscle contact With this refinement in technic the radical operation might be said to be beyond criticism Symmetry of the face is conserved as there is no atrophy of the temporal muscle there is no deviation of the jaw since the pterygoid muscles are intact ; and mastication is in no way interfered with

Later in the same year he wrote

> The exposure of the motor root is so easily obtained that one wonders why for so many years it was needlessly sacrificed
> This is of advantage not only from the standpoint of cosmetics or of the greater ease of mastication but also because it at once solves the problem of how to deal with bilateral trigeminal neuralgia

In 1929 however in considering the function of the mesencephalic root and fearful that afferent fibers might be contained in the motor root Frazier came to a somewhat different conclusion Whether or not the premises justify the deduction I have of late abandoned my previous practice of conserving the motor root in radical operations for trigeminal neuralgia Nevertheless in subsequent reports he still referred to preservation of the motor root

In reviewing the literature on the various procedures which had been attempted for the relief of trigeminal nuralgia Tiffany reported a mortality rate of 22 per cent for gasserian ganglion operations a figure which Spiller (Frazier and Spiller 1902) considered so high that the neurologist refers his patients with tic douloureux to the surgeon with great hesitation

We are further indebted to Tiffany for the principle of saving the motor root though this contribution too seems largely to have been overlooked The earliest suggestion of the possibility was made in the first of three papers (1894) appearing in three successive years Commenting on one of the four cases upon which he had operated up to that time Tiffany wrote When dividing the third division of the nerve in Case 4 I believe that I isolated and recognized the motor branch before dividing it Not having provided myself with a sufficiently long and fine electrode I could not prove the accuracy of my opinion by electric stimulation and therefore divided everything By leaving intact the motor branch the patient would not have food collect in the cheek of the paralyzed side and in the future operations an effort should be made towards this end

The idea is again brought forward two years later when Tiffany reviews his own experience and that of others The expediency of attempting to save the motor fibers accompanying the third branch may be considered Usually I have not taken the pains to do so yet I have thougnt that I recognized them Reference is then made to a case (106 of the collected series but Tiffany s own second case) in which the muscles of mastication were made to contract again and again by passing a tenaculum under the third branch close to the bone And it was perfectly evident says Tiffany in his report of the case that had it been desired the motor branch could have been left intact Finally reference is made to a case of bilateral trigeminal neuralgia Lately (Case 108) comes the suggestion that an operation may be expedient on both gasserian ganglia and if so a bilateral paralysis of the muscles of mastication would be unfortunate While the necessity for a bilateral operation is remote yet the Hartley Krause operation will be more complete if the motor root is spared and I think it can be

CHAPTER XII

SUBTEMPORAL TRIGEMINAL DORSAL ROOT SECTION

As appears from the preceding pages, Frazier was the first to put into effect Tiffany's suggestion that the ophthalmic fibers be saved in order to conserve the innervation of the cornea. This procedure Frazier defined as *subtotal resection* of the sensory root, saying "by this expression I imply leaving one of the inner fasciculi intact. . . . It is not at all a difficult matter to isolate the innermost fasciculus of the sensory root as implied in subtotal resection."

Since in a number of patients pain may for many years be limited to a single division of the trigeminal, Stookey (1928) recommended a further refinement of dorsal root section which he termed *differential section*, implying thereby that when pain was limited to one division only the fibers from that division in the trigeminal dorsal root need be sectioned, leaving intact the remaining fibers and thereby limiting the area of sensory loss. Thus, if pain involves the third division, the fibers in the dorsal root derived from that division are sectioned, leaving intact those from the second and first divisions. Similarly, fibers from the second or the first division may be severed without interference with those of the other two.

Fortunately the arrangement of fibers in the dorsal root *close to the gasserian ganglion* corresponds fairly accurately to the three divisions of the trigeminal nerve. The ophthalmic division is smaller than the maxillary and the maxillary is smaller than the mandibular. These same proportions hold true within the dorsal root. Selection of the fibers from the third and the first divisions can be made with a fair degree of accuracy. Isolation of those from the second is more difficult and more subject to error. In a few patients in whom differential section of the second division has

For continued advancement in the field of trigeminal surgery we are deeply indebted to Spiller and Frazier whose work has been so remarkably productive Throughout the years from Frazier s first successful trigeminal dorsal root section on October 12 1901 a series of stimulating studies in this field has been presented No two men have contributed more to the advancement of this branch of neurosurgery Happily the work so well begun has been carried on at the University of Pennsylvania with equal distinction by Francis Grant and his confreres

believe with Adson that stimulation of the motor root is not only a tedious procedure tending to prolong the operation but that the results are uncertain and may even be misleading

Frazier's attitude in this matter of motor root preservation has already been discussed We have considered it essential at

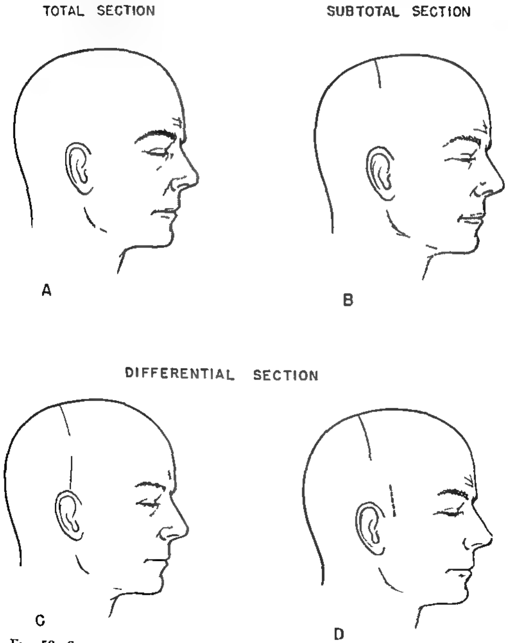

Fig 52 Sensory loss after A total section B subtotal section C and D differential section

been done only blunting of sensation has been obtained but pain has nevertheless been abolished Occasionally all the fibers within the root will appear as a compact unit rather than as discrete bundles For this reason we have never felt justified in assuring the patient in advance that differential section will be done

There remains always the chance that the pain may extend into another division or that if all the fibers are not severed recurrence may take place These possibilities should without fail be made clear to the patients in advance In our experience they have been more than willing to face the risk of recurrence and those in whom reoperation has become necessary have been grateful for the limited loss of sensation and willing again to submit to surgery

Fig 51 Photograph of patient showing area of sensory loss after differential section of mandibular fibers within the dorsal root (Area of sensory loss on scalp due in part to operative incision)

Reference has been made above to Tiffany s suggestion that the motor root be spared Peet (1918) was the first actually to put this into practice He reported saving the motor root in five of eight trigeminal dorsal root sections Adson (1922) exposed the motor root and identified it by retracting the mesial aspect thus revealing the separate motor fibers beneath and independent of the sensory root Neither Peet nor Adson found it necessary to stimulate the motor root for its identification since this was sufficiently clear by its position and character Most surgeons

believe with Adson that stimulation of the motor root is not only a tedious procedure tending to prolong the operation but that the results are uncertain and may even be misleading

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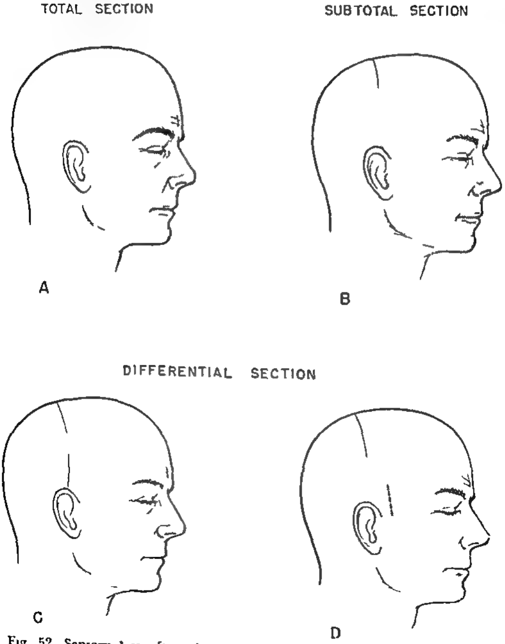


Fig 52 Sensory loss after A total section B subtotal section C and D differential section

least to make the attempt in view of the ever present possibility of bilateral neuralgia Furthermore as has been said by preservation of the innervation of the temporal masseter and pterygoid muscles atrophy is avoided a better cosmetic result is obtained and the masticatory function is saved

Selection of Patients for Operation Patients have been accepted for section regardless of age or physical condition—even those with such disabilities as severe hypertension coronary disease hemiplegia or renal insufficiency alone and in combination—since we believe that only operation will afford permanent relief and that cessation of the unbearable pain is imperative If the patient has not been able to eat or drink is dehydrated and has high blood pressure a day or two in bed with glucose intravenously phenobarbital and a good sleeping potion has been helpful by way of preparation for operation

Fig 53 Photograph of patient with mouth open Motor root spared jaw does not deviate

Many of our patients could not or at least preferred not to survive if permanent relief could not be given The majority had suffered for a number of years alcohol injections had afforded only temporary relief and finally none at all so that operation offered the only hope of surcease It is true as Grant has stressed that trigeminal neuralgia is not a fatal disease and therefore measures must be taken which afford the greatest likelihood of success with the minimum risk This in our opinion is most

readily achieved by subtemporal trigeminal dorsal root section In evaluating our results and operative mortality the fact that no selection of patients has been made must be taken into consideration, though in this respect we offer no apologies

Special Instruments In any clinic where trigeminal dorsal root section would be undertaken the requisite special equipment is available The particular instruments are merely a matter of preference on the part of the surgeon

An adequately lighted field is essential This may be obtained by lighted retractors or by outside lights either a head lamp or properly placed floor lamps We prefer outside lights since if the field suddenly becomes bloody from the middle meningeal artery the illumination from a lighted retractor is often obscured at the very moment when it is most needed

We have found a few small dental tools invaluable in plugging the foramen spinosum and in separating the dura from the bone after the trephine opening has been made Suction apparatus and cautery are very important as are also small pledgets of Gelfoam

Position of the Patient The patient is placed in a modified dental chair which was adapted by the senior author in 1922 and is still in use The chair rests on a platform with rollers to permit easy movement A posterior attachment for an adjustable head rest was made and an adjustable arm holds a small instrument table The arms are removable to facilitate placing the patient in and taking him out of the chair Without disturbing the sterile field the back of the chair can be lowered if need be to bring the patient into a prone position and can be elevated as desired as the operation progresses A lower upright position is used until the foramen spinosum is identified and plugged This is usually followed by gradual elevation by use of the foot pedal so as to keep the operative field at a level with or slightly higher than the surgeon s eyes thus giving him visualization of the field without stooping For closing the incision the chair is again lowered so as to have the field at a convenient level

The head is placed with the zygoma parallel with the floor and turned slightly toward the side of the operation thus allow-

ing blood and spinal fluid to drain away from the operative field A canvas piece over the face holds the head in position The legs are wrapped with elastic bandages and maintained at an elevated angle The drapes are accordion folded to allow for change in position from sitting to recumbent While there has rarely been need for such a change provision should be made to permit it

Fig 54 Patient in position for subtemporal exposure of the gasserian ganglion and trigeminal dorsal root The head should be slightly tilted toward operative side to allow blood and fluid to gravitate from incision The legs should be elevated and elastic bandages applied The drapes are accordion folded over small table to permit patient to be placed in reclining position or if need be in Scultetus position

Anaesthesia Local anaesthesia has been used almost exclusively The age and physical condition of many of the patients would in our judgment make operation under a general anaesthetic too hazardous irrespective of the skill and resourcefulness of the modern anaesthetist and the newer anaesthetics available

On entering the hospital the patient receives phenobarbital which is continued until the night preceding operation when

a sleeping potion is given at 9 P M , with instructions that this is not to be repeated during the night In the morning an hour and a half before the patient is brought to the operating room, 200 mgm of sodium luminal is administered hypodermically No other medication is given until the patient is in the operating chair ready to be taken into the operating room Either 10 mgm or 15 mgm of morphine and 0 4 mgm of scopolamine is then given An intravenous solution of 5 per cent glucose in saline is introduced to be available as required

Local Anaesthesia The incision is marked upon the skin at the level of the zygoma and about 2 cm in front of the external auditory meatus, extending upward for 5 cm directed slightly posteriorly so as to avoid the motor twig of the facial to the frontalis muscle A needle is inserted immediately below the zygoma the skin is infiltrated with 1 per cent procaine hydro chloride and the needle gradually carried through the deeper structures to the temporal bone The needle is then partially withdrawn to infiltrate the skin and muscle both in front and behind the outlined incision This maneuver, properly done will give complete anaesthesia down to and including the bone No pain will be felt during trephination or on exposure of the dura until the middle meningeal artery is reached A small pledget of cotton dipped in procaine hydrochloride can be held against the vessel at this time or after exposure of the foramen spinosum While pain from the middle meningeal may still be present it will last but a few moments it is not as severe as the attacks of neuralgia and is generally well tolerated As soon as the foramen spinosum is plugged and the middle meningeal cut the mandibular division at the foramen ovale is immediately injected The injection is made under pressure so as to carry the anaesthetic solution to part of the gasserian ganglion which can be injected again as it is exposed By injecting the mandibular division under pressure slight bleeding arising from the small vein and artery accompanying this division is checked

If local anaesthesia is properly applied pain is felt only for a few moments during exposure of the middle meningeal and again for a second or two while the anaesthetic is being introduced into the third division and the contiguous portion of the gan

glion The surgeon or the anaesthetist may be tempted to give additional morphine at the first complaint of pain arising from the middle meningeal Since this pain is of brief duration and injection of the mandibular division will afford complete anaes thesia it is best not to add to the medication especially in the older age group

The role of the anaesthetist is an important one and a sympa thetic and co operative attitude on his part is of great help It is he who reassures the patient and follows his general condition blood pressure and pulse rate during the course of the operation A sudden fall in blood pressure may occur when the root is cut While this is usually of little significance the anaesthetist should be forewarned of the possibility and should be prepared to cope with it Suitable medication should be available in a syringe for immediate use should the condition become alarming

Usually the nasal mucosa is sprayed with procaine hydro chloride and a catheter introduced so that oxygen may be given throughout the operation since the circulation of air beneath the drapes is likely to be hindered

The Incision The skin incision is carried to the temporal fascia the superficial temporal artery being caught with forceps and coagulated The fascia is cut slightly lateral to the incision in the skin and a small transverse nick is made in the fascia at its attachment to the zygoma so as to allow for wider separation The temporal muscle is split following the direction of its fibers and is held with two blunt retractors and peeled off the temporal bone with wet gauze and a periosteal elevator With the use of gauze the scratching noise of instrument against bone which may be annoying to a patient under local anaesthesia is avoided After the muscle has been sufficiently separated an automatic retractor is introduced and the bone is exposed as low as the zygoma

Removal of Bone An opening in the bone is made with a burr care being taken to avoid tearing the underlying dura which in elderly patients is often adherent to the bone The lateral or squamous portion of the temporal bone beneath the temporal muscle just above the zygomatic process in the region exposed for trephination may be extremely thin often only

1 or 2 mm, or it may be as thick as the cranial vault itself The bone is ronguered so as to make an opening about 3 to 4 cm in diameter, carried as near to the floor of the middle fossa as possible Occasionally air cells are opened, in which event they should be closed at once with bone wax In the dolichocephalic skull the floor lies deeper than in the brachycephalic and below the level of the zygoma so that it cannot be as conveniently reached This makes separation of the dura and retraction to expose the foramen spinosum a little more difficult

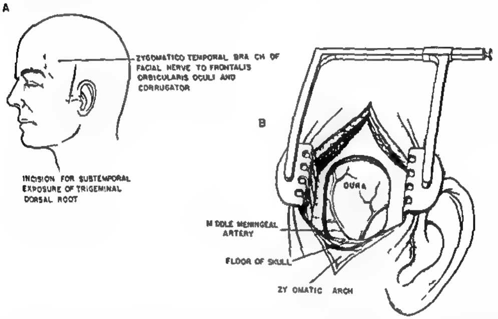


Fig 55 A Line of incision placed so as to avoid zygomatic temporal branch of the facial nerve to the frontalis muscle B Opening through skull exposing the dura and middle meningeal As soon as the opening in the bone is made great care should be taken to avoid tearing the dura in separating it from the bone A tear in the dura at this stage may continue to the ganglion and make satisfactory exposure difficult

Floor of the Middle Fossa No region of the skull shows so many minor variations as the area brought into view in the subtemporal approach to the foramen spinosum and the gasserian ganglion and its divisions Trivial though these variations appear their presence may be a source of difficulty to the surgeon

The floor of the middle fossa is made up of the union of two bones—the petrous portion of the temporal and the sphenoid

The gasserian ganglion lies upon the former and the maxillary and mandibular divisions pass through the latter

The sphenoid is formed from fourteen centers of ossification Two of these appear during the second month in the chondrocranium of the alisphenoid One center lies between the maxillary and mandibular divisions forming the foramen rotundum The other forms the foramen ovale between the foramen rotundum and the foramen lacerum The foramen spinosum is usually formed in the alisphenoid but may develop in the temporal bone The mandibular nerve lies in a groove upon the alisphenoid

Determinations of the size of the foramen spinosum ovale and rotundum and their *relation to one another and to the* depression for the gasserian ganglion were made in a series of forty skulls Not only did the size shape and position of the foramina vary from one specimen to another but inequalities were also noted in the two sides of the same skull The various measurements are indicated in the accompanying schematic sketch

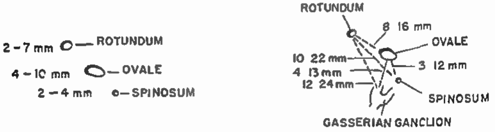


Fig 56 Schematic drawing indicating variations in size of the foramen spinosum ovale and rotundum and their varying distances from the gasserian ganglion

Added to variation in position size and shape of the foramen spinosum are differences in position size and shape of the middle meningeal artery which passes through this opening The foramen ovale may carry a small accessory meningeal branch of the internal maxillary artery or this branch may arise directly from the internal carotid and replace the middle meningeal The surgeon should have in mind this abnormal position of the middle meningeal artery Occasionally a small opening is found mesial and slightly behind the foramen rotundum the foramen of Vesalius for passage of a small vein At times this may be

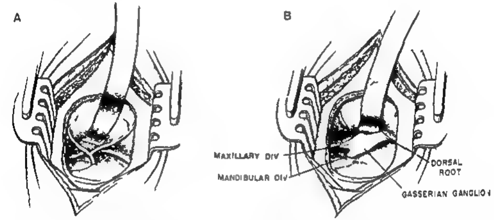
sufficiently large to cause annoying though easily controlled bleeding

The ganglion as indicated above lies in a slight depression in the petrous portion of the temporal bone behind the emerging nerves and upon the foramen lacerum which may be covered by a fibrous membrane of variable thickness or by a layer of thin bone forming a roof over the internal carotid artery A forward prolongation of the dura from the posterior fossa forming a dural sheath surrounds not only the ganglion but also the three divisions as they make their exit through the foramina in the sphenoid bone Lateral to the ganglion the floor may be extremely thin and at times deficient

The medial extremity of the petrous bone joins the basilar portion of the sphenoid According to Goldstein (1910) from birth to adult life rotation of the petrous portion of 10°—20° in an anterior direction occurs with development of the cerebellum due to the intimate and close attachment of the posterior border of the dura of the tentorium to the petrous ridge which has a tendency to pull forward the mesial part of the ridge with its fixed point at the basisphenoid The direction of the petrous bone and the angle formed with the basisphenoid are not the same in the narrow (dolichocephalic) and the broad (brachycephalic) skull In the latter the petrous ridge has a more rostrad position and the foramen rotundum and foramen ovale are farther apart than in the narrow skull

The minor variations in position and direction of the foramina attributable to developmental factors as well as the elevations and slight protuberances in various positions on the floor are in general of minor importance though an elevation obscuring the foramen spinosum or the foramen ovale may at times make exposure of these two openings somewhat tedious Small sharp saw tooth edges of bone found on the lateral portion of the temporal bone and along the floor may cause difficulty in separation of the dura which may be deficient or extremely thin over these projections and easily torn A small ridge along the dorsal root may separate the fibers of the ophthalmic from the maxillo mandibular and still more rarely a ridge may divide the mandibular from the maxillary

Exposure of the Foramen Spinosum The dura and brain are gently retracted, the dura being elevated from the floor of the middle fossa. The middle meningeal can usually be followed to the foramen spinosum. As soon as the foramen is exposed it is plugged with a small pledget of cotton. If either the foramen spinosum or the foramen ovale is obscured by an elevation of bone so as to interfere with exposure, the protuberance can be chiseled off, though this is seldom necessary. Of greater significance are the variations in size, shape and position of the foramen spinosum. The foramen may be so small that plugging it with cotton is difficult, or it may be extremely large, raising some doubt as to the value of such a plug.



EXPOSURE OF MIDDLE MENINGEAL ARTERY AT FORAMEN SPINOSUM

LINE OF INCISION IN DURA PROPRIA OVER GANGLION AND ROOT

Fig 57 A Exposure of the middle meningeal artery at the foramen spinosum. The foramen is then plugged with a small pledget of cotton or a curved director is held in the foramen and cautery applied. B Exposure of the gasserian ganglion and dorsal root

As the third division is more completely brought into view it is again injected under pressure as mentioned above, so as to include part of the ganglion, and as the ganglion is further exposed it also is injected. The operation can then be continued without pain except possibly at the instant the fibers in the dorsal root are sectioned. Even at this point pain can be avoided by holding a pledget of cotton dipped in procaine hydrochloride upon the root when it is exposed.

Exposure of the Ganglion The ganglion is exposed by finding the line of cleavage between the dura propria and the overlying dura This is best done with a dull elevator or a small moist dental roll held by forceps In this manner the overlying dura is separated first over the third division and then from the dura propria of the ganglion It is seldom necessary to separate the overlying dura from the second division Attention has already been called to the possibility that the dura of the middle fossa overlying the ganglion may be torn In that event exposure of the ganglion becomes more difficult

The dura over the anterior surface of the petrous bone lying posterior and beneath the ganglion should not be disturbed since it covers the great superficial petrosal nerve If however the nerve is exposed it is best to cut it with a sharp knife to avoid traction upon it which may cause swelling of the geniculate ganglion and secondary pressure upon the facial nerve

With the ganglion brought into view the temporal lobe and dura overlying the root are sharply elevated by means of a retractor with a slightly curved edge which can be hooked under the reflected temporal dura The dura propria enclosing the root is then exposed It is to be remembered as previously shown that the dura enclosing the dorsal root the ganglion and the trigeminal divisions is carried forward from the posterior fossa into the middle fossa where it is overlaid by the dura of this latter structure When the line of cleavage between the dura propria and the dura of the middle fossa is found exposure of the ganglion and root is readily accomplished Not infrequently due to previous inflammation or to alcohol injections the two layers may be adherent and difficult to separate

Before proceeding further all bleeding should be under control even slight oozing must be arrested This is readily achieved by judicious application of one or two small pledgets of Gelfoam Some of the minor venous channels too inconstant and too small to be identified may cause enough oozing to be annoying Occasionally bleeding from the venous channels near the maxillary division may be troublesome

Exposure of the Dorsal Root The root and its sheath are exposed for a distance of 0 5 cm behind the ganglion It is not

necessary to carry the exposure ar far as the petrous ridge To do so is likely to cause bleeding from the superficial petrosal sinus Furthermore if a differential section is planned the fibers belonging to each of the three divisions are more accurately identified nearer to the ganglion

The dura propria enclosing the trigeminal root is then opened with a small hooked knife It is first slit parallel to the root following which a small transverse incision is made These two incisions into the dural covering give a more complete exposure of the root and permit more accurate identification of the funiculi The cerebrospinal fluid is readily aspirated and a dry field maintained by suction

Exposure of the Motor Root The motor division should now be identified and saved This may be accomplished by lifting the mesial part of the root downward and outward as suggested by Adson The motor root will be seen lying along the medial border as a separate funiculus consisting of either one or two bundles of a somewhat whitish opaque appearance quite different from the afferent fibers both in color and direction

In approaching the dorsal root from the mesial aspect unless the motor fibers proximal to the ganglion along the mesial border are recognized they may readily be included in the hook lifting the sensory root If therefore they are not immediately seen the root should be released and another attempt made to bring them into view

Section of the Sensory Root If a total resection of the sensory root is to be made the mesial approach to expose the motor root is to be preferred but if a differential section is planned it is best to select the fibers to be sectioned along the lateral border of the root lifting the root to visualize the motor fibers and then cutting the afferent fibers with a sharp knife or scissors The guillotine knife developed by Hyndman allows selective section without traction upon the fibers A few fibers may adhere along the dural roof and escape section when it is thought that all fibers have been visualized and sectioned Fibers may also adhere to the mesial wall of the dural sheath Caution must be observed in atempting to reach these lest the mesial dural wall and cavernous sinus be torn This probably occurred with

disastrous results in one patient in an attempt to reach one or two fibers which it was thought remained attached to the wall

Unless care is taken in selecting the fibers for differential section traction on them may accidently avulse more fibers than had been planned since in some cases the fibers are held closely together consequently we prefer to section rather than avulse If the bundles however are obviously separate from each other the desired fibers may be avulsed rather than *sectioned* By avulsion the fibers are withdrawn from the brain stem which removes even the most theoretical possibility of regeneration Where total resection is to be done we prefer avulsion rather than section

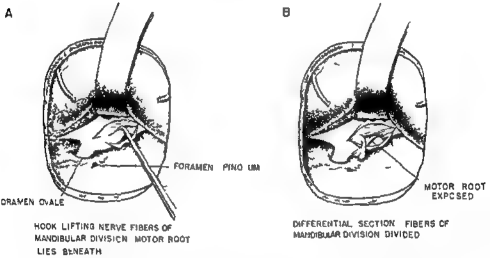


Fig 58 A Dorsal root exposed and fibers from the mandibular division separated preparatory to dorsal section B Mandibular fibers sectioned exposing motor root

Fibers from the third division are identified with relative ease Selection of fibers from the second division cannot be made with equal accuracy but a fair approximation can usually be achieved If too many fibers are selected some may be included which belong to the ophthalmic On the other hand in the effort to avoid that mishap too few may be taken For this reason differential section of the second division fibers alone should be tried only in relatively young patients since in this group if pain returns operation can be repeated years later In elderly patients

on the other hand the possible requirement of a second operation at a later date should be avoided

In the choice of differential rather than subtotal section one is always faced with the possibility at a later date, of involvement of an adjacent division or of missing some fibers belonging to the division intended to be severed In the event that reoperation is required it can readily be performed since the middle meningeal artery need not be dealt with and exposure of the ganglion and root is easily accomplished The only difficulty and this is trivial is freeing the muscle and dura from the bony opening in the skull

The possibility of reoperation is fully explained to the patient along with the advantages of limited loss of sensation When recurrence of pain has taken place, or extension into another division reoperation has been gladly accepted and has presented no problem

If the motor division is inadvertently severed this need not mean permanent loss of motor function Obviously the motor cells and axons up to the point of severance remain intact thus permitting regeneration of the fibers To facilitate this the severed division should be replaced within the dural sheath We have seen restoration of motor function under these circumstances Scar tissue does not intervene as in peripheral nerve lesions and the smooth dural sheath and arachnoid bathed in cerebrospinal fluid offer an ideal medium and pathway for regeneration of the motor fibers

While the severed afferent fibers may show histologic evidence of regeneration locally for the reestablishment of transmission of afferent impulses it would be necessary for the fibers not only to penetrate the local glial scar but also the pia glial limiting membrane at their previous point of entry into the brain stem and in addition to reestablish their central connections No evidence has been found to suggest that this takes place

Regeneration due to Scattered Ganglion Cells Unsuccessful dorsal root section with return of sensation has been attributed by some to regeneration of nerve fibers due to the presence of ganglion cells scattered along the trigeminal dorsal root Peters (1935) found ganglion cells in the central portions of the trigem

inal dorsal root in a number of animals, including man, and in one a minute accessory ganglion within 2 mm of the gasserian ganglion but not connected with it On the basis of his morphological studies he was of the opinion that ganglion cells on the root central to the point of surgical section might account for return of sensation after operation Though Tower (1931) and Paskind (1936) found numerous regenerating nerve fibers following dorsal root section they noted that *none* penetrated through the root entry zone An occasional fiber could be seen to enter with the blood vessels but none was able to break through the pia glial limiting membrane to establish central connections essential for return of function

Some of the fibers of the dorsal root occasionally lie along the roof of the dural sheath enclosing the root and may be overlooked by the surgeon To avoid this the ganglion is gently depressed with a small cotton wall off and a hook is then passed along its top into the dural sheath to bring into view any fibers which may have become temporarily adherent to the roof

With the patient under local anaesthesia sensation in the various divisions may be tested with a pin before the operation is concluded to make sure that all of the fibers to be sectioned have been cut This is especially desirable in differential section of second division fibers

After the surgeon has satisfied himself that all of the fibers intended for section have been cut and that all bleeding points have been controlled a small amount of saline solution can be injected into a nick made in the dura This tends to replace the lost cerebrospinal fluid and to bring the dura back into position against the floor of the middle fossa All bleeding should be controlled The sites calling for inspection are the retracted dura one or two small venous channels along the course of the middle meningeal artery the foramen spinosum and the region of the maxillary division A small rubber band is left as a drain for twenty four hours and a skin suture is placed to be tied when the drain is removed

When for one reason or another the dura is torn and cannot be separated an intradural approach as originally recommended by Horsley may be done After the temporal lobe was retracted

and the floor of the middle fossa brought into view, Horsley identified the upper border of the petrous bone using this as a guide to the fifth nerve The position of the canal in which the nerve is lying just above the ganglion must then be estimated and a small puncturing incision made into it As it is about a quarter of an inch in diameter it can be recognized as soon as the puncturing instrument passes into it and the dura forming its roof should then be further slit open The nerve in this way is exposed and is found to be freely lying in the little passage

Fig 59 Photograph of patient while still in operating chair immediately after dorsal root section under local anaesthesia

Because of bleeding and difficulty in separating the dura and to avoid damage to the great superficial petrosal nerve Schorcher (1942) and Wilkins (1948) prefer the intradural route to reach the ganglion and dorsal root In a personal communication Wilkins (1957) expresses the opinion that with this approach the motor division can more regularly be preserved and a more accurate subtotal resection done We have used this procedure only when for one reason or another it has been forced upon us by an adherent and friable dura Our preference is for the extradural route

CHAPTER XIII

POSTOPERATIVE COMPLICATIONS OF SUBTEMPORAL DORSAL ROOT SECTION

Certain complications may follow section of the trigeminal sensory root These are peculiar sensations paraesthesias and dysaesthesias in the distribution of the trigeminal nerve a temporary facial paralysis and finally loss of sensation to the eye These possibilities we have always discussed thoroughly with the patient before operation emphasizing the risks so that there can be no misunderstanding on his part

It is stressed that any one or all three of these complications may develop and that while every effort will be made to do a subtotal or differential section we cannot be positive that a total resection will be avoidable Occasionally the fibers in the dorsal root are so matted together especially after repeated alcohol injections that in spite of all that can be done they cannot be satisfactorily separated and a total resection of the sensory fibers may result with consequent loss of sensation to the face and cornea Patients thus prepared for the worst are willing to accept even total resection and make the necessary mental adjustment rather than endure longer the frightful pain of trigeminal neuralgia

A clear understanding of the potential unfavorable consequences of the operation especially of the possible paraesthesias will not only make for an easier postoperative adjustment but will engender a valuable spirit of cooperation between patient and surgeon The confidence thus inspired will serve to offset erroneous prophecies of such dire results as permanent paralysis of the face loss of the eye and persistence of the pain

The trigeminal patient has usually run through the gamut of remedies—operations upon the sinuses extraction of teeth alcohol

injections with subsequent recurrence of pain various medicaments and repeated injections of vitamins—before seeing the neurosurgeon In desperation he undertakes this last consultation with skepticism and hopelessness that cannot be considered unjustified in view of all the therapeutic failures to which he has been previously subjected The one exception is the patient who has had personal contact with another who has been relieved of pain following trigeminal dorsal root section The prospect is then viewed with confidence unbounded hope and enthusiasm with the realization that at long last his unbearable suffering can be brought to an end Many of our patients have been referred not by our medical colleagues but directly by other patients which is the supreme tribute to the value of the operation We have found that those who are in doubt as to the procedure and its outcome obtain the greatest satisfaction and assurance by seeing and talking to a fellow sufferer who has already undergone operation There may be a patient in the hospital or one who has been operated upon several years earlier who is delighted to explain the procedure and its after effects Whenever possible we have urged a patient who has been misinformed concerning the operation to talk to one or two former patients Nothing the surgeon can say is as reassuring as the enthusiastic encouragement given by some one who has been relieved of his suffering Here indeed seeing is believing This point is well illustrated by a patient who upon advice had refused to submit to the operation Subsequently she had two alcohol injections and on two occasions section of the supraorbital and infraorbital nerves When the pain returned she happened to meet a patient upon whom we had operated twelve years previously All doubts were now eliminated and a dorsal root section was demanded!

Paraesthesias The simplest explanation of the paraesthesias to be given to the patient is to compare them with the effects of procaine Most of the patients will have had one or more tooth extractions and will be familiar with procaine injections They are reminded of the peculiar sensations experienced on these occasions—the feeling that the lips were thick and swollen the difficulty of rinsing the mouth the failure to feel the rim of the glass on the side of the injection They will themselves

recall that a glance in a mirror revealed no change in appearance and that in spite of lack of feeling the movements of the lips were normal and unimpaired It is explained that following operation for trigeminal neuralgia the face may similarly feel tight or swollen or drawn or that possibly a crawling sensation may be experienced These are the inevitable price the patient may have to pay to be rid of the pain If he makes up his mind to face the situation he will soon become accustomed to the altered sensations and gradually they will cease to be annoying It is imperative to make the patient realize that he *must* choose between these paraesthesias and a continuation of his pain He must become a partner in the solution of his problem It may appear that undue stress has been placed on this point but we cannot over emphasize the importance of *preparing* the patient and helping him to make the necessary mental adjustment *in advance*

With this portrayal the patient usually understands the sensory changes which follow and is ready to accept them without having to go through the painful procedure of a preliminary injection of alcohol to acquaint him with the numbness to be expected In many instances in which the senior author has declined to give an alcohol injection the patient has gone elsewhere for injection only to return for operation Said one I only wish you had hit me over the head with a club and *made* me have the operation

In spite of our best efforts however there are a few patients who find adjustment difficult usually those of advanced years with cerebral arteriosclerosis whose minds are not equal to the strain of adaptation to new situations or those whose personal or family problems complicate the situation In some of these the paraesthesias may become an obsession Nevertheless when the problem has not become too acute the suggestion impossible though it be that we put the nerve together again and thus restore sensation *and* the old pain is usually followed by an entire change of attitude and a more satisfied outlook since *any* inconvenience is regarded as better than a return of the former suffering

The senior author is reminded in this connection of an elderly

man who had undergone a dorsal root section at the hands of one of the senior surgeons at the old Neurological Institute in New York with establishment of complete anaesthesia The patient continued nevertheless to haunt the hospital Because of his repeated complaints operation was again undertaken—this time a cervical sympathectomy which was then considered to offer a possible cure The results were disappointing and further aid was sought at a clinic in a neighboring city Here the carotid artery was stripped and the surgeon wired hopefully Delighted to report your patient completely free from pain This assurance appears however to have been somewhat premature for in a month the patient was back at the Institute complaining as before Finally he came under the care of a neurologist who had little more success than his surgical confreres One day on encountering the old man he assumed an air of great confidence —whatever his inner reservations may have been—and handed the patient a prescription with the assurance that with this medicine your pain will disappear The patient s thanks were profuse then suddenly crestfallen he drew from his pocket a sheaf of prescriptions bearing Philadelphia New York and Boston addresses Running through these he regretfully handed back the latest one with the explanation I tried that two years ago and it s no good! Fortunately such an obsessive response is rare One might question the diagnosis yet the pain in all its manifestations indicated typical trigeminal neuralgia For some of this group Sir James Paget s comment concerning pain is particularly appropriate For pain expected watched for long thought of will come will come in or from the nerve centers and be as bitter as any from the nerve ends and conversely the longer and more often the attention can be diverted from any pain the less does the power of discerning pain become

Facial Paralysis The appearance of facial paralysis after subtemporal dorsal root section has been a distressing but fortunately almost always a temporary complication restoration of function taking place within a few weeks rarely after a longer interval A number of theories have been advanced to explain this occurrence Obviously the facial nerve cannot be injured directly either within the cranium or in its extracranial course The

paralysis must therefore be a secondary phenomenon In rare instances the petrous bone is defective over the geniculate ganglion in others seepage of blood through tiny foramina into the temporal bone and facial canal may cause pressure upon the tightly enclosed facial nerve

Adson (1919) thought that avulsion of the trigeminal dorsal root from the brain stem rather than section of the root might contribute to the production of facial paralysis Frazier (1921) believed that lack of ample room in the operative field might be responsible I know he wrote since I have adopted the flap method and have had ample access without retraction there has not been a single instance of facial paralysis in a series now including more than 121 consecutive operations The most commonly accepted view is that traction upon the great superficial petrosal nerve results in edema with secondary compression of the facial nerve at the geniculate ganglion The paralysis rarely appears at the time of operation being usually observed two or three days after operation rarely as late as the seventh day

It was Dixon (1897) who first suggested the possibility of injury to the facial nerve at the geniculate ganglion by traction on the great superficial petrosal nerve His suggestion is supported by the observations of others Alfred Taylor in a personal communication many years ago advised division of the great superficial petrosal nerve so as to avoid traction upon it Frazier later (1931) cautioned against stripping the dura from the anterior surface of the petrous ridge particularly the triangular space posterior to the ganglion so as to prevent traction or injury to the great superficial nerve thereby avoiding facial paralysis This procedure is now generally followed Gardner Stowell and Dutlinger (1947) reported the occurrence of peripheral facial paralysis seven times in thirty one sections of the great superficial petrosal nerve when the nerve was elevated and subjected to traction before it was divided the paralysis usually appearing about the fourth day When however the nerve was sectioned in its groove without traction the incidence of facial paralysis was reduced

Recovery from facial paralysis is hastened if it is recognized in its earliest phases and treatment begun at once At the

slightest suggestion of facial weakness it has been our practice to support the muscles to prevent sagging of the angle of the mouth (see Fig 60) This is accomplished by applying a strip of mole skin adhesive beginning at the angle of the mouth and connecting this by a small rubber band with another piece of moleskin or gauze fixed with collodion to the temporal region thus furnishing an elastic support to the facial muscles It is important to see that the angle of the mouth is pulled *up and not backward,* as may occur if the strapping is not properly placed Tension on the rubber band must be maintained so that there is no sagging at any time An extra turn or two over the small safety pin attached to the strip upon the temporal region will take up any slack which may have developed

Occasionally an *apparent* facial weakness due to altered proprioceptive sense may at first be indistinguishable from the earliest suggestion of a true facial paralysis Rather than waiting to see if this apparent weakness becomes a true paralysis the surgeon should strap the face immediately If no facial weakness develops within forty eight hours the strapping is removed and nothing is lost On the other hand it is our belief that recovery is appreciably hastened by applying the strapping in the earliest stages Hence we are not concerned when within a day or two we find that actually no paralysis has developed

In addition to this measure cortisone 50 mg twice daily for the first two or three days is given followed by 50 mg daily for the next ten days With this regime recovery usually takes place within two to three weeks seldom later and more often earlier

Temporary facial paralysis occurred in 7 8 per cent of our cases While some residual weakness remained in seven patients or 0 98 per cent no disfiguring permanent paralysis resulted It is our belief that recovery is not only hastened but is greatly facilitated by the treatment outlined

Deafness Rarely after operation the patient may complain of a sense of fullness in the ear and transient slight deafness on the operated side attributable to the presence of blood or cerebrospinal fluid behind the ear drum as a result of seepage through the roof of the tympanic cavity either from small emissary open

ings or a slight defect in the overlying bone Lyons (1923) suggested that these complications were due to secretion of fluid as a result of trophic disturbance of the mucous membrane of the middle ear secondary to section of the dorsal root It is doubtful however if the mucous membrane is supplied by the trigeminal nerve certainly not in its entirety Two of Lyons patients are said to have complained of water in the ear The tympanic

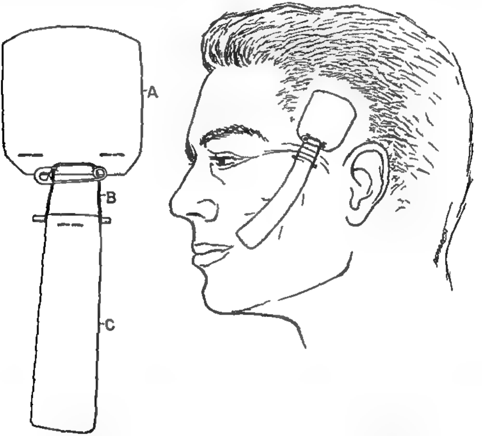


Fig 60 Method used to support facial muscles A piece of moleskin or gauze (A) applied with collodion is used as an anchor attached to the temporal region A strip of moleskin or gauze (C) is applied to the face beginning at the angle of the mouth so placed as to pull *chiefly upwards* Care must be taken to avoid pulling the face backwards A small piece of wood is incorporated in the facial strip and a safety pin in the anchor The two are then connected by a *small* rubber band (B) twisted over the safety pin to elevate the angle of the mouth Care must be taken from time to time to maintain elevation by an extra twist of the rubber band over the safety pin If gauze is used compound tincture of benzoin should first be applied to the skin

slightest suggestion of facial weakness it has been our practice to support the muscles to prevent sagging of the angle of the mouth (see Fig 60) This is accomplished by applying a strip of mole skin adhesive *beginning at the angle of the mouth and connecting* this by a small rubber band with another piece of moleskin or gauze fixed with collodion to the temporal region thus furnishing an elastic support to the facial muscles It is important to see that the angle of the mouth is pulled *up and not backward,* as may occur if the strapping is not properly placed Tension on the rubber band must be maintained so that there is no sagging at any time An extra turn or two over the small safety pin attached to the strip upon the temporal region will take up any slack which may have developed

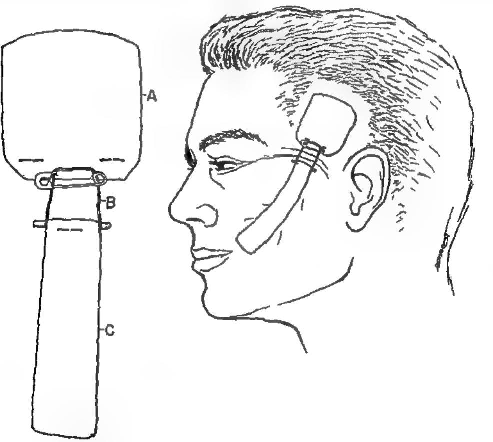
Occasionally an *apparent* facial weakness due to altered proprioceptive sense may at first be indistinguishable from the earliest suggestion of a true facial paralysis Rather than waiting to see if this apparent weakness becomes a true paralysis the surgeon should strap the face immediately If no facial weakness develops within forty eight hours the strapping is removed and nothing is lost On the other hand it is our belief that recovery is appreciably hastened by applying the strapping in the earliest stages Hence we are not concerned when within a day or two we find that actually no paralysis has developed

In addition to this measure cortisone 50 mg twice daily for the first two or three days is given followed by 50 mg daily for the next ten days With this regime recovery usually takes place *within two to three weeks seldom later and more often* earlier

Temporary facial paralysis occurred in 7 8 per cent of our cases While some residual weakness remained in seven patients or 0 98 per cent no disfiguring permanent paralysis resulted It is our belief that recovery is not only hastened but is greatly facilitated by the treatment outlined

Deafness Rarely after operation the patient may complain of a sense of fullness in the ear and transient slight deafness on the operated side attributable to the presence of blood or cerebrospinal fluid behind the ear drum as a result of seepage through the roof of the tympanic cavity either from small emissary open

ings or a slight defect in the overlying bone Lyons (1923) suggested that these complications were due to secretion of fluid as a result of trophic disturbance of the mucous membrane of the middle ear secondary to section of the dorsal root It is doubtful however if the mucous membrane is supplied by the trigeminal nerve, certainly not in its entirety Two of Lyons patients are said to have complained of water in the ear The tympanic



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membrane was gray or pink with a fluid level and fullness of the lower quadrant Pressure on the tympanic membrane by the otoscope caused the fluid to shift This probably was cerebrospinal fluid

Gardner and Babbitt (1929) believed the hemorrhage to have its origin from a small branch of the middle meningeal vein which makes its exit from the middle ear through the hiatus Fallopii Ody (1943) also called attention to hypoacousis and blood in the middle ear and found that catheterization of the eustachian tube relieved the deafness

Occasionally slight bleeding from the nostril may take place due to minimal trauma by the patient to the insensitive mucous membrane Rarely cauterization of a minute bleeding point is required

Interstitial Keratitis When Magendie cut the trigeminal nerve in rabbits intracranially the eye was rapidly destroyed Claude Bernard (1858) repeated the experiment of his master and noted that the eye first became injected the cornea lusterless the pupil constricted and the convexity of the cornea increased Both Magendie and Bernard found that when the nerve was cut behind the ganglion the destructive changes were slower in appearing and concluded that the ganglion cells had a trophic influence on the cornea Snellen (1858) demonstrated that if the ear of the rabbit were sutured over the eye keratitis did not occur Similarly in man if the eyelids are closed keratitis disappears promptly

In the analgesic cornea keratitis has been attributed to trauma associated with loss of the defense reflex to diminution of reflex movements of the eyelids and consequently less frequent bathing of the cornea and to diminished tearing Rowbotham (1939) has shown that while injury to the great superficial petrosal nerve lessens the flow of tears the secretory function of the lacrimal gland is not altogether abolished and that some other mechanism takes over so that the eye is kept moist In their thirty one sections of the great superficial petrosal nerve previously mentioned Gardner Stowell and Dutlinger reported two instances of keratitis in a normally sensitive cornea indistinguishable from that following resection of the trigeminal dorsal root

and concluded that the condition is due to drying of the cornea The keratitis promptly disappeared when evaporation was retarded by sealing the eye behind a watch crystal On the other hand instances of keratitis have occurred in the insensitive cornea following trigeminal tractotomy where the great superficial petrosal nerve could not have been injured and tearing consequently not diminished

Taking into consideration all of the circumstances under which keratitis has been observed *analgesia* of the cornea emerges as the *sine qua non* in its production Trauma diminished tearing and less frequent reflex movements of the lids are contributing causes particularly trauma Since then analgesia and trauma are the primary causes of keratitis these are to be avoided by maintaining the innervation to the cornea whenever possible as originally suggested by Tiffany either by subtotal resection or differential section of the trigeminal dorsal root

The patient is warned not to rub the eye but to close the lid and pat it gently with a handkerchief so folded that the edge cannot strike the cornea He is also taught while still in the hospital preferably before the operation to use an eye cup to bathe the eye with boric acid solution With the eye closed and the head bent forward he places the eye cup in position then raises the head opens and closes the eye repeatedly a few times and again lowers the head to remove the cup With the lid closed the eye is then gently patted with a folded handkerchief This may be repeated two or three times a day for the first month or two

It is our practice not to close the eye or apply a shield after operation If however the eye shows any evidence of injection it is promptly closed with a small gauze butterfly fastened to the tarsus of the upper lid with a touch of collodion when this is dry the lower half of the butterfly is fastened with collodion to the cheek—which is slightly elevated—care being taken that the two lids are brought together but neither *inverted* nor *everted* In forty eight hours the gauze can be removed The conjunctiva will usually be found to be clear by this time if not the butterfly is replaced Obviously in applying collodion care must be taken not to get it into the eye or on the lashes

Both the patient and the family are instructed to watch the

eye and if any injection appears to report to the hospital where the resident is instructed to close the lid with a small butterfly An ophthalmologist unfamiliar with the process may apply a patch over the eye without ensuring that the lid is closed Since gauze may then come in contact with the insensitive cornea we regard the method we have described as the one of choice

Fig 61 A gauze butterfly is attached with collodion to upper lid over the tarsus Allow time for it to dry The skin below the eye is then slightly elevated and the lower part of the butterfly attached to the cheek care being taken not to *invert* or *evert* either lid The cheek is gently supported until the collodion is dry The butterfly is made by using fine mesh gauze cut as shown twisted two or three times and tied with a fine thread The twist is made so that two fifths of the butterfly is above and three fifths below the center portion

Here again it is essential that the patient understand these points in the care of the eye *before* the operation even though a subtotal or differential section is planned since, as has been said it is not always possible to preserve the ophthalmic fibers

If a total resection has been performed and unfortunately a temporary facial paralysis develops the *lids must be sutured* usually allowing a small peephole and closure maintained so

long as the paralysis persists If the lids and conjunctiva are inflamed prior to operation, every effort should be made to clear up the injection before operation

In our series keratitis developed in 7 patients or 0 98 per cent, with some permanent diminution of visual acuity in 2 patients or 0 028 per cent In no instance was enucleation of the eye necessary The results obtained we attribute to the instructions given the patient and prompt temporary closure of the eye

Harris (1940) reported that stellate ganglionectomy diminished the liability of keratitis and that with this procedure the small nasal ulcerations which occasionally follow alcohol injection into the gasserian ganglion heal more readily McKenzie (1955) refers to a personal communication from Dott saying that whenever he sections the ophthalmic fibers or injects the ganglion with alcohol he resects the superior cervical ganglion Following this procedure he had never as far as he knew had a case of corneal ulceration

We have had no experience with this procedure While slight injection of the cornea may appear shortly after the operation and during the first two or three months keratitis has not been a serious postoperative problem possibly because the patient has been thoroughly instructed in the care of the eye and cautioned to be alert to notice the *first* suggestion of any injection which is then *immediately* taken care of No patient in our series has ever lost an eye nor have we had any series ulcerations With the rarest exceptions tarsorrhaphies have been done only when facial paralysis has been an associated complication of total dorsal root section If however the care of the eye is neglected and prompt temporary closure of the lids omitted tarsorrhaphy must be performed

The essence of successful care of the eye is *early* recognition of the slightest conjunctival congestion and prompt temporary closure by application of a gauze butterfly If early closure of the lids is done healing is prompt

Herpes Simplex Herpetic eruptions occurring after forty eight to ninety six hours have been a frequent and annoying though trivial complication of dorsal root section for the relief of trigeminal pain The eruption involves the lips and the skin about the

alae nasi and chin and heals promptly, in five or six days leaving no scar In the past, most neurosurgeons attributed the eruption to damage to the gasserian ganglion and its extent was thought to be in proportion to the degree of trauma inflicted during the process of uncovering the ganglion The appearance of similar eruptions however when the dorsal root was cut in the posterior fossa and following tractotomy has made this concept no longer tenable The problem has intrigued a number of workers, notably Goodpasture Teague Richter Epstein Slavin and Ferguson and more recently Carton and Kilbourne

In Cushing s 1920 report of twenty gasserian ganglionectomies he mentioned the occurrence of herpetic lesions in two patients These were present not only in the trigeminal area but also in the sacral region In one instance the herpetic vesicles were on the unoperated side on the upper lip and ala nasi In the second patient who had had a previous peripheral neurectomy of the supraorbital and infraorbital nerves the eruption did *not* occur in the denervated area but on the chin in the distribution of the intact mandibular division

Goodpasture and Teague (1923) stressed the importance of the trigeminal nerve and gasserian ganglion as the pathway of invasion of the herpes virus They held that the virus enters the nervous system by invasive proliferation along the axis and cylinders extending centrifugally from the ganglion along the nerve to the skin to produce active eruption Teague and Goodpasture (1923) emphasized the different clinical and cultural features of herpes zoster and herpes simplex but were nevertheless able with virus from a patient with *atypical* herpes in the distribution in the supraorbital nerve in the frontal region to produce typical simplex herpetic eruptions in the guinea pig (in thoracic areas which previously had been shaved covered with a thin layer of tar and scarified) and on the scarified cornea of the rabbit The patient from whom the virus was obtained did not have typical herpes simplex nor were the lesions typical of herpes zoster The virus was transplanted in series in the first two rabbits keratitis developed but no encephalitis the third died of herpetic encephalitis As a result of their experiments Teague and Goodpasture concluded that herpes simplex and herpes

zoster may be caused by the same virus of varying degrees of virulence or by closely related viruses

Slavin and Ferguson (1950) also stressed the differences between the zoster and simplex viruses simplex being readily transmitted to animals whereas zoster is not They believed however that both viruses may stem from a common ancestor which is in accord with the view of Teague and Goodpasture

Richter (1944) was unsuccessful in attempts to grow herpes simplex virus from the ganglion and dorsal root of five patients and concluded that the virus is not stored in an inactive state in the trigeminal nerve or in the gasserian ganglion as had been held by some He considered it more likely that an alteration of the metabolic state of the skin following the trigeminal operation predisposed to an invasion of the virus from an external source He reported typical herpetic eruptions following a transfrontal operation upon a pituitary tumor and attributed these to indirect traction or pressure upon the trigeminal nerve

Epstein (1948) in a survey of 772 trigeminal operations including subtemporal and posterior fossa dorsal root sections as well as tractotomies found herpetic eruptions in 143 or 18 5 per cent All three operations were subject to this sequela but the incidence was greater in subtemporal than in suboccipital dorsal root sections

Carton and Kilbourne (1952) and Carton (1953) reported the occurrence of herpetic vesicles in 97 7 per cent of subtemporal dorsal root sections with involvement not only of the labial region but also the palate and mucous membranes within the oral cavity They were able to recover herpetic simplex virus from the herpetic vesicles but not from the ganglion or nerve tissue

While it is generally accepted that the primary herpetic simplex infection occurs in childhood as an acute stomatitis Kilbourne and Horsfall (1951) cited instances of primary infection in adults showing vague clinical signs suggestive of infectious mononucleosis The primary infection is followed by persistence of the virus in the tissues in a latent form where it remains indefinitely giving rise to high titre specific antibodies for years or even for life The virus was first thought by some to be in the ganglion and to migrate centrifugally along the neuron

Cultures from the ganglion and root however, have been universally unsuccessful and it is now generally believed that the virus in its latent form is in the peripheral tissues Recurrent episodes of labial herpes occur spontaneously without known cause in healthy individuals and may also be precipitated by a number of extraneous agents such as pneumonia aspirin penicillin and artificially induced fevers as well as by operations upon the trigeminal ganglion and dorsal root either before the fibers enter the brain stem or within the brain stem Indeed, eruptions have been reported about as frequently following tractotomy as after dorsal root section

Fig 62 Patient with herpes simplex following subtotal dorsal root section

Carton holds that previous intact neurons are essential to virus activation and called attention to the fact that if the fibers of the maxillary or mandibular divisions have been previously destroyed subsequent operation upon the dorsal root is generally not followed by herpes simplex eruptions He cites Furlow s practice of injecting alcohol into the mandibular or maxillary divisions intracranially just peripheral to the ganglion prior to closure after subtemporal dorsal root section If herpes appeared it was always present in the distribution of the division that had not been injected

The occurrence of herpes simplex after trigeminal tractotomy is not surprising since in this operation the central arms of the peripheral neuron are severed The integrity of the neuron is

altered whether these fibers are severed in the middle fossa at the pons or within the brain stem Changes in the cell body are greater the closer the section is made to the ganglion

Carton and Kilbourne suggest that following trigeminal operations the virus is activated *in situ* as a result of local changes in tissue metabolism secondary to interference with the afferent neuron The activating factor in the absence of local trauma to the afferent neuron has not been determined It has been suggested that interference with the neuron with consequent deneration is not an essential factor for the appearance of herpetic eruptions since they occur under a variety of conditions in which presumably the integrity of the neuron has not been disturbed

Amos (1953) has shown that phosphatase enzymes added to suspensions of the virus are capable of destroying its infectivity and that some molecule essential to infectivity is active only in a phosphorylated form

Mortality In considering our mortality cognizance must be taken of the fact that there was no selection of cases according to age or physical fitness A total of 728 operations was done Six deaths occurred in the series or 0 82 per cent (see Statistics p 302) Jefferson (1931) has aptly stated that it is only common sense to admit that occasional fatalities must occur when we are dealing with persons of the age and debility of some neuralgias

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brought to Tiffany s attention in response to a questionnaire that prompted his suggestion that the motor root be saved

Bullock (1905) described a patient weighing 300 lbs three months pregnant who had pain in the entire distribution of the right trigeminal and two and one half years later in the left mandibular division The left inferior dental nerve was resected and four weeks later the right gasserian ganglion was removed giving the patient complete freedom from pain until her death six months later in uremic coma

Bilateral trigeminal neuralgia whether both sides are involved simultaneously or successively is a formidable disability presenting a problem calling for a high degree of judgment and skill The possible consequences of bilateral loss of sensation and the inherent threat of bilateral damage to the motor innervation of the muscles of mastication have apparently made surgeons reluctant to operate While reports of many unilateral trigeminal operations appear in the literature detailed accounts of bilateral operations and their end results are extremely rare although in approximately 2 to 5 per cent of the cases both sides are involved

Only two *detailed* operative reports of transtemporal bilateral dorsal root section had appeared prior to the senior author s report of four cases in which he had performed bilateral differential dorsal root section for trigeminal pain (Stookey 1955) In a review of his entire series nine additional bilateral cases were found making a total of thirteen or 1 9 per cent in nine of which differential dorsal root section was done In spite of the fact that this series extends over a thirty year period the incidence is lower than has been generally conceded One patient had pain starting on one side and switching after four years to the other The second side was operated on and there has been no further pain on either side during the intervening ten years In one the pain appeared on the opposite side thirty two years after the original operation

Since four of the operated cases have already been reported it seems worthwhile to record the results in the additional five and to present the entire series in tabular form showing the end results in those on whom bilateral operations were done We have been able to procure recent photographs of three of the additional five cases

CHAPTER XIV

BILATERAL TRIGEMINAL NEURALGIA—SURGICAL TREATMENT

The surgical treatment of bilateral trigeminal neuralgia was made possible by Tiffany's (1896) prescient suggestion that the motor fibers be spared in order to avoid paralysis of the muscles of mastication and by his insistence on saving the ophthalmic fibers (*i e*, subtotal section) in order to prevent involvement of the eye and anaesthesia of the cornea Without these two basic concepts bilateral trigeminal neuralgia would not be amenable to surgical treatment

Bilateral trigeminal neuralgia was reported by Krause and by Winslow in the same year (1896) Krause's patient began having pain in the right second division at the age of thirty four Six years later in 1887 the right infraorbital nerve was resected Within nine months pain developed in the opposite infraorbital *region cheek nose and lip This pain disappeared spontaneously* but excruciating pain on the right side returned in 1894 Krause then resected the right gasserian ganglion Two months later pain again appeared on the left side while the operated side continued to be painless Krause offered no suggestion for further treatment but thought that the bilaterality of the disease indicated a central focus He had nothing to say concerning the preservation of the motor division

Winslow's patient thirty one years old had left sided paroxysmal *pain in all three divisions continuing for four years* In August 1896 after ligating the nerves Winslow cut them at their entrance to the foramina into which he pushed the distal ends he then curetted the gasserian ganglion thus producing freedom from pain on the operated side Eight months later however pain developed on the opposite side of the face It was this case

The reports and follow up visits of these patients revealed a happy, well adjusted group whose attitudes refute the dire predictions forecast for them For example M G wrote I am very thankful for the success of the operations and feel I live a normal useful life now There are no visible changes in my face When I m in New York I would like to come to see you Mrs C P reported I am pleased to say that I am in very good health my face is in quite good shape I get along fine eating Mrs T E was seen in the clinic in 1957 where she was cheerful and cooperative She had no pain and reported that she ate her food without spilling and enjoyed every mouthful (See Table 2)

Fig 63 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia Photograph 24 years after operation

I can eat anything I want but cut pieces from an apple instead of biting into it and break off pieces of bread When corn on the cob is served it is cut off for me Nothing unusual is noticed about my eating (26 years after second operation)

Stookey *J Neurosurg* 1955 Courtesy Charles C Thomas Publisher Springfield

Cushing (1920) in a series of 332 cases found one of bilateral pain following herpes zoster which of course is not true trigeminal neuralgia In a footnote however he mentioned another patient in whom there were definite bilateral symptoms at the time of operation but no indication was given that a bilateral operation had been performed for pain on the opposite side

Frazier and Russell (1924) in an analysis of the symptoms

TABLE 2

SUMMARY OF BILATERAL TRIGEMINAL CASES

Age at Onset of Pain on First Side		Division at Time of First Operation	Date First Operation	Interval Between Onset in First and Second Sides	Interval Between First and Second Operations	Division at Time of Second Operation	Age at First Operation	Date of Second Operation	Age at Second Operation	Remarks
F W	M 35	R 1 2 3	1925	35 yr		L 3	43	—	—	
J E	F 44	R 2 3	1926	17 yr	5 yr	L 3	56	1931	61	Reported at 86 yr No pain eats anything My greatest trial is having so little to do Died Summer 1957
C P	F [illegible]	R 1 2 3	1929	8 mo	5 yr	L 2 3	61	1934	66	Reported at 67 yr Complete relief Eats without difficulty
T L	F 30	R 2 3	1930	same time as first side	2 yr	L 2 3	40	1932	12	Reported at 67 yr No pain eats well enjoys food
B H	M 47	L 2 3	1931	11 yr	14 yr	R 3	49	1945	[illegible]	Reported at 73 yr Works on floor of Stock Exchange talks a great deal eats anything can taste all foods
J S	M 29	R 2 3	193[illegible]	26 yr	14 yr	L 2	47	1916	61	Reported at 72 yr Very happy no pain slight dribbling of food on right side
J B	F 53	L 1 2 3	1933	3 yr 4 yr	5 yr 13 yr	R 2 R 3	53	1938 1946	58 66	Reported at 75 yr No pain keeps mostly to soft foods can eat anything Most grateful
V J	M 51	L 1 2	1940	12 yr	3 yr	R 1 2	63	1943	66	Reported at 77 yr No pain no difficulty with vision eats well
M G	24 F 31	R 2 R 2	1939 1944	7 yr 3 mo	7 yr 2 yr	L 3	33 34	— 1916	— 40	Reported at 51 yr Occasional slight pain in right eye otherwise fine no trouble eating
A T	F 50	L 2 3	1942	1 yr		R 2 3	70	—	—	
R R	M 46	R 3	1947	3 yr	3 yr	L 3	55	1950	58	Reported at 62 yr No pain spills food unless careful working as salesman
A S	F 56	R 1 2	1951	1 yr		L 2	62	1956	64	
M K	F 42	R 1 2 3	1947	6 yr	1 operation	0	18	0	—	No further pain on either side

Dandy (1929) reported that he had encountered three cases of bilateral trigeminal neuralgia In one seen before he had developed the posterior approach to the trigeminal dorsal root, he did not operate lest the motor root be destroyed The other two patients he operated upon successfully cutting both dorsal roots simultaneously in the posterior fossa One patient included in Lewis and Dandy s (1930) study of taste referred to elsewhere (p 74) had pain in all three divisions on the right side for twenty one years and in the second and third divisions on the left for six years Later (1945) Dandy made the simple statement, twenty operations were satisfactorily done

Fig 61 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia Photograph 9 years after operation

At 76 I am working and free of pain I keep mostly to soft bland foods but can eat anything cutting meat into small pieces I occasionally drool but manage very well prefer to eat in front of a mirror—a small matter Every thought of you is a prayer (11 years after second operation)

Stookey *J Neurosurg* 1955 Courtesy Charles C Thomas Publisher Springfield

Horrax and Poppen (1935) who operated upon 176 patients in a series of 468 with major trigeminal neuralgia reported bi

and distribution of the pain in 754 cases of trigeminal neuralgia made no mention of bilateral involvement Subsequently Frazier (1934) reported that he had seen twenty three patients with bilateral trigeminal neuralgia representing about 1 per cent of the 2 198 cases on the records of the Neurosurgical Clinic of the University of Pennsylvania Hospital which he had classified as major trigeminal neuralgia Five of Frazier s patients were operated upon No statement is made concerning the treatment of the remaining eighteen Grant (1938) however presumably referring to this same group stated that five were relieved by bilateral operation two received bilateral alcohol injections and in ten operation was done on one side and when the pain re appeared on the opposite side it was checked by alcohol block An average of four years and four months elapsed between relief of pain on one side and its appearance on the other the shortest period being nine months and longest twelve years The operations on the opposite side according to Frazier were done one two three five and eight years after the first intervention in two of the five the outer two thirds of the sensory root was divided on each side in two the outer two thirds was divided on one side and the middle third on the other in one the outer two thirds on one side while the outer two thirds of the ganglion was resected on the other

Unfortunately Frazier gave no details as to the disability which followed bilateral sensory loss and the problems confronting his patients Mixter however in discussing Frazier s paper referred to four cases in which bilateral operations had been done two by his father and two by himself He stated that the patients had lost the sense of position of their mouths to such an extent that all of them had to use mirrors in relearning how to eat Some of our patients also found this procedure of aid until they had become adjusted

Adson (1926) encountered thirteen instances of bilateral trigeminal neuralgia in 829 patients Curiously enough the pain in the majority occurred simultaneously on both sides but was of different intensity This was true of Krause s patient and also of two of ours In one of Adson s cases the pain appeared on the opposite side seven years after the first attack

years (in one instance thirty seven years) before the development of pain on the second side, suggesting that the eventual incidence would be even greater because of the probability that in a number at least of the younger group the previously unaffected nerve would become involved This point is stressed also by Peet and Schneider (1952) At the time of original examination, 2 7 per cent of their series of 689 patients had bilateral pain but on follow up some years later bilateral involvement was found in 5 9 per cent

Fig 65 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia Photograph 6 years after operation

My speech is normal I have formed good eating habits and am not uncomfortable in company while eating During past twelve years have missed only one day for sickness (12 years after second operation)

Stookey *J Neurosurg* 1955 Courtesy Charles C Thomas Publisher Springfield

Wertheimer and Descotes (1957) reviewing 500 case records found thirteen instances of bilateral pain Two patients had pain on both sides when first seen one refused operation and the other was treated by peripheral neurotomy on the left side This unilateral section gave complete relief on *both* sides for eight years after which pain recurred on the right side and was again relieved by peripheral neurotomy In five of the thirteen

lateral pain in nineteen or 4 1 per cent No indication was given, however, that any of these was operated upon nor was any reference made to the type of treatment employed

Coleman Meredith and Troland (1948) performed 200 unilateral operations in a series of 600 patients with major trigeminal neuralgia and reported a single instance of bilateral dorsal root section without furnishing details Indeed they considered it one of the distinguishing features of true trigeminal neuralgia that the pain is unilateral in distinction to atypical neuralgia and psychogenic facial pain

Davis and Naffziger (1948) reported on 245 patients of whom nine or 3 6 per cent had bilateral involvement Of the total number, 179 were operated upon but no statement was made as to treatment in the bilateral cases

Olivecrona (1931) encountered two instances of bilaterality among sixty radical operations for trigeminal neuralgia In one of his patients the right dorsal root had been sectioned by another surgeon in 1914 This procedure was followed not only by recurrence of pain in the right but also by pain in the second branch on the left Accordingly a radical section of the dorsal root had been done including both sensory and motor fibers This appears to have given permanent relief on the right but pain on the left continued An intracranial section of the left second division was done in 1928 but two years later when the patient was seen by Olivecrona he was suffering frightful pain in this area The left dorsal root in the posterior fossa was then cut and the patient was at last completely relieved of his suffering

While the second of his patients did not come to operation Olivecrona indicated that had this been the case he would have cut the dorsal root *via* the posterior approach because of the presumed preservation of tactile sensation by this route and the ease with which the trigeminal motor root may be saved

Harris (1940) found eighty five cases of bilateral trigeminal neuralgia in his series of 1 433 or 5 3 per cent Unfortunately however there were included in the bilateral group fourteen cases of multiple sclerosis reducing the number of cases of true bilateral trigeminal neuralgia to seventy one and the percentage to 4 9 In some of Harris s patients there was a lapse of several

years (in one instance thirty seven years) before the development of pain on the second side suggesting that the eventual incidence would be even greater because of the probability that in a number at least of the younger group the previously unaffected nerve would become involved This point is stressed also by Peet and Schneider (1952) At the time of original examination 2 7 per cent of their series of 689 patients had bilateral pain but on follow up some years later bilateral involvement was found in 5 9 per cent

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Wertheimer and Descotes (1957) reviewing 500 case records found thirteen instances of bilateral pain Two patients had pain on both sides when first seen one refused operation and the other was treated by peripheral neurotomy on the left side This unilateral section gave complete relief on *both* sides for eight years after which pain recurred on the right side and was again relieved by peripheral neurotomy In five of the thirteen

cases a bilateral *total* dorsal root section was done, through a sub temporal approach with preservation of the motor root Although transient difficulty in chewing occurred in some, there was no permanent difficulty Bilateral *total* dorsal root section neverthe less presents a formidable risk which could be lessened by bi lateral differential section

Frazier s (1926) report of his first operation for bilateral trigem inal neuralgia by the transtemporal approach is worthy of review The patient a woman fifty one years of age had been operated upon for major trigeminal neuralgia on April 12 1917 an evulsion of the left sensory root being done under ether anaesthesia Since this was before it had become a matter of routine to save the motor root no attempt was made in that direction and on the patient s second admission in May 1926 the muscles on the side of the previous operation showed complete degeneration At that time she was suffering paroxysms of major trigeminal neuralgia involving the right maxillary division which had first made their appearance in 1924 seven years after the original operation on the left Though Frazier had frequently preserved the motor root after 1919 he was fearful that in this *particular instance he might somehow fail Knowing that the* muscles of mastication were completely paralyzed on the left side he was not eager to assume the responsibility of an accidental injury to the motor root on the right It was only after the patient had refused alcohol injection and had actually signed a written statement relieving the surgeon of all responsibility that on June 19 1926 he undertook a subtotal section of the right sensory root by the usual transtemporal approach The outer two thirds of the sensory root was sectioned leaving the motor root un disturbed But though the motor root was plainly seen by the operator and the assistant its continuity plainly in evidence the patient was unable immediately after the operation to approxi mate the jaws Frazier was confident however of his success and as the course of events proved with justification for on the seventh day the patient began to recover function of the paralyzed muscles and before discharge the jaws could be approximated and the ability to masticate food had been re established

One of the advantages of the suboccipital approach has been

held to be the ease with which the motor root can be saved Actually in experienced hands it can be spared as readily by the subtemporal route which also permits differential section of the dorsal root with greater certainty, since the correspondence of the fibers within the root to the three divisions of the nerve is closer near the ganglion than it is more distally The advantage of this in bilateral cases where preservation of sensation is of paramount importance is obvious

Fig 66 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia Photograph 5 years after operation

Careful in putting food in mouth to avoid some appearing on lips (7 years after second operation)

Stookey *J Neurosurg* 1955 Courtesy Charles C Thomas Publisher Springfield

Following the proposal by Sjoqvist (1938 1939) that the descending trigeminal tract be sectioned for the relief of trigeminal pain detailed reports of the treatment of bilateral trigeminal neuralgia began to appear Weinberger and Grant (1943) reported one case involving the right second and third divisions and the *left* second division On the right side the entire sensory root was sectioned *via* the posterior route producing complete anaesthesia while on the left side tractotomy was performed resulting

A

B

Fig 67 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia

A Photographs taken at time of first operation (1930)

B Photograph 1957—twenty seven years after first operation

Can chew food on both sides once in a while a little food may fall out of mouth but I manage very good I suffered a heart attack a few years ago which accounts for my thin face as I lost thirty pounds " (25 years after second operation)

in hypalgesia in the *first division*, with moderate hypalgesia in the third division and *only mild hypalgesia* in the second division Grant considered the operation unsuccessful since, at the end of nine months pain had begun to return

Olivecrona (1942) sectioned the descending trigeminal tract in four patients with bilateral trigeminal neuralgia In the first two patients the operation proved a complete or almost complete failure as only slight to moderate hypalgesia in the affected divisions resulted and in both there was a recurrence of pain In the last two the procedure was more successful In one especially a satisfactory degree of analgesia was obtained on both sides with no return of pain after eight months Postoperatively gait and station were normal in daylight though there was some slight impairment in walking after dark The other patient was free of pain after a year but her sense of balance left much to be desired though she could walk without support she complained of giddiness

Falconer (1949) reported two cases of bilateral trigeminal neuralgia treated by tractotomy The first patient who was fifty years old had had pain in the third division for five years several alcohol injections had been given and intracranial section of the third division on the side of involvement had been performed three years before Tractotomy was done on one side at two levels one 2 mm and another 4 mm below the obex A year and a half later the patient was re admitted with severe pain in the second division on the opposite side for which alcohol injection had been given fifteen months previously A tractotomy was then performed on the second side 3 mm below the obex and the pain was relieved At the time of Falconer s report the patient had been followed two years after the first operation and three months after the second The general impression of the end result was good Slight tingling in the trigeminal area remained

Falconers second patient was a tabetic who had had a successful alcohol injection of the gasserian ganglion for trigeminal neuralgia a year previously Following this severe pain developed in the opposite second division Accordingly tractotomy was done three cuts being made one at 2 mm another at 4 mm and an

other at 6 mm below the obex in two different operations The patient was relieved but complained of slight aching in the trigeminal area and an increase of ataxia in the ipsilateral upper extremity At the time of the report he had been followed for four months without return of pain

Fig 68 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia Photograph 12 years after operation
It is twelve years since the last operation I am now 74 I spill food from my mouth occasionally I sure thank you for both operations

Raney *et al* (1950) reported one bilateral tractotomy The patient was sixty seven years old and had suffered from repeated bilateral trigeminal attacks for several years Alcohol injections had been limited to the maxillary divisions since it was thought that mandibular injection might paralyze the motor division After bilateral tractotomy analgesia of both trigeminal zones was obtained but no indication is given as to the period of observation after operation nor of the area of lost sensation

It is significant that in only two of the patients on whom tractotomy was done for relief of bilateral trigeminal pain was the ophthalmic division involved yet one of the most constant findings has been analgesia of the entire ophthalmic area and

loss of the corneal reflex which should if at all possible be preserved It is particularly unfortunate to sacrifice the ophthalmic division and the corneal reflex needlessly, since by subtotal or differential dorsal root section *via* the transtemporal approach the ophthalmic fibers serving the cornea can generally be preserved and the corneal reflex maintained The presumed advantage of retention of tactile sense by tractotomy does not apply to the cornea since it has been amply demonstrated that this receives only pain fibers

Fig 69 Patient with differential trigeminal dorsal root section for bilateral trigeminal neuralgia Photograph 12 years after operation

No trouble eating Am most grateful In 12 years I have had no pain

Harris s cases were treated by alcohol injection either into the division involved or into the ganglion When the ganglion was injected Harris reported paralysis of the muscles of mastication

See pages 228 229 230 and 231 →

Fig 70 A B C D Figures illustrating divisions involved in 12 bilateral operations for bilateral trigeminal neuralgia Left hand figure of each indicates division in which pain first appeared and right hand figure division subsequently affected The ophthalmic division was never involved when pain appeared on opposite side Either subtotal or differential section was possible on the opposite side thus minimizing the sensory loss

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FIG 70 A

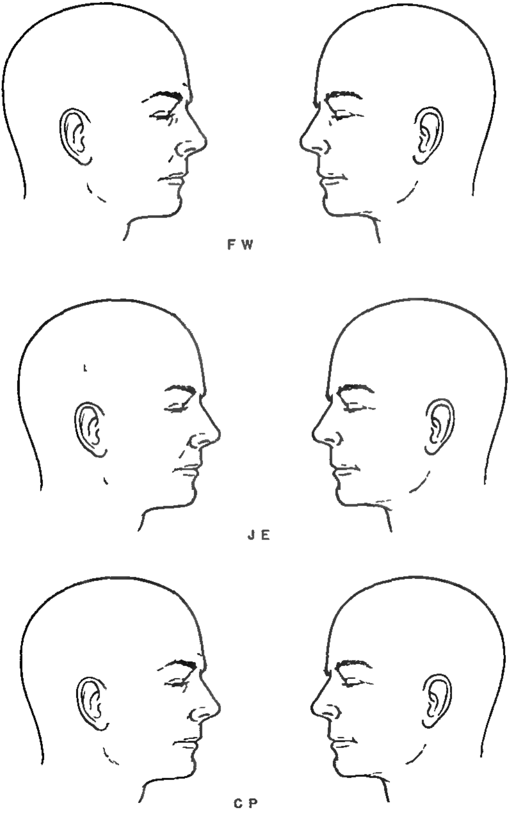


FIG 70 B

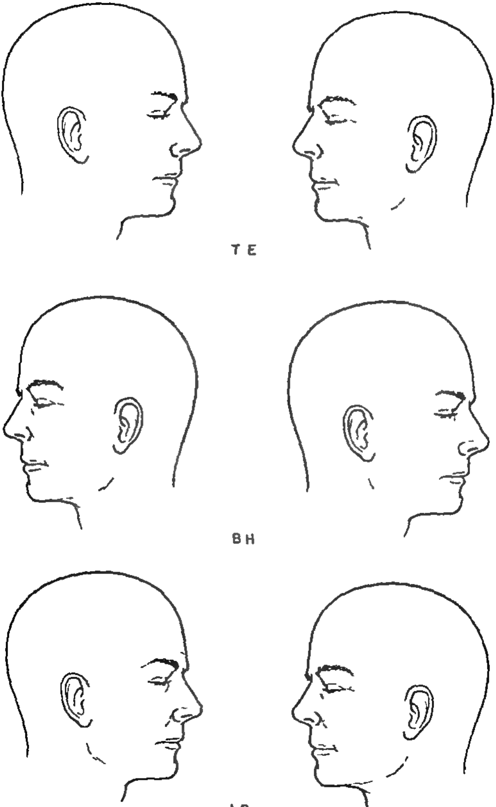
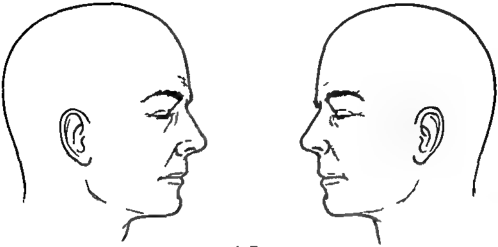
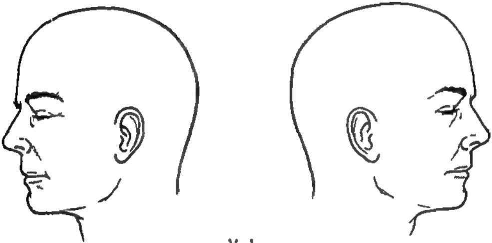


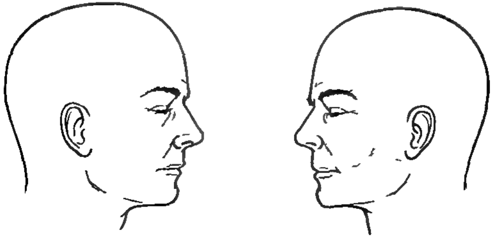
FIG 70 C



J B

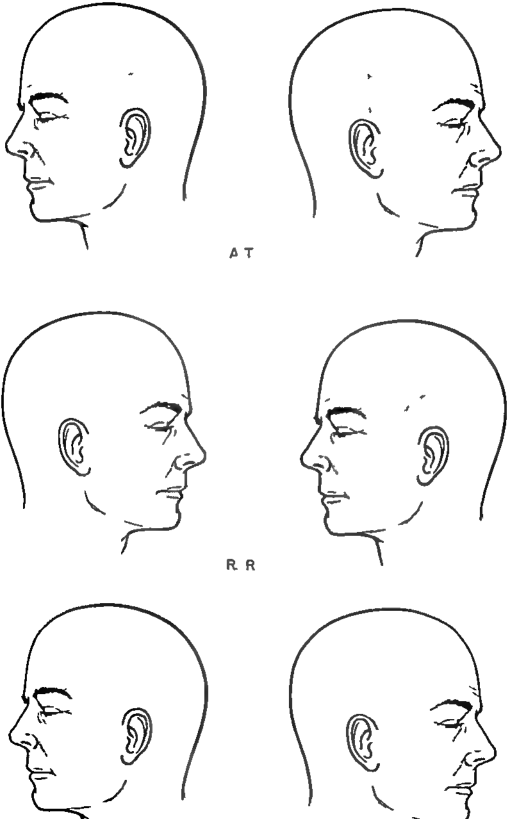


V J



M G

FIG 70 D



which he stated *generally* recover in two or three months (*italics are the authors'*) Obviously, if the muscles are paralyzed on one side injection on the opposite side is out of the question On the other hand loss of the motor division on one side does not contraindicate subtotal or differential section on the other—whether by the subtemporal or suboccipital approach—since with these procedures the remaining motor root can be spared Needless to say the operation demands the greatest skill and is not to be undertaken without full realization of the hazards

Harris sent a questionnaire to 765 patients who had good anaesthesia following gasserian ganglion injections for pain in various divisions Replies were received from 475 Three hundred sixteen reported no recurrence of pain for a period of three years or more of whom six had had bilateral injections The duration of relief in these six cases is given as follows

Right	*Left*
18 years	16 years
16	14
13	6
5	5
5	3
5	4

Thus in Harris's hands destruction of the ganglion cells by alcohol injection can be said to have resulted in permanent relief in bilateral trigeminal neuralgia It may be that injection of hot water as recommended by Jaeger will prove eventually to give comparable longlasting relief

In the treatment of bilateral trigeminal neuralgia much depends on the age and condition of the patient In those of advanced age much can transpire in four or five years during which time alcohol injection on the second side may suffice to give permanent relief This view however must be weighed against the probability that operation may eventually be unavoidable when the patient will have attained a more advanced age and surgery be a still greater hazard

On the basis of one bilateral dorsal root section in the middle fossa White and Sweet (1955) were convinced that this operation is inadvisable no matter how skillfully it is carried out

They reported that fluids ran out of the patient's nose which is something that never happened in our experience Nor have any of our patients complained that eating was as if shoveling food *into a void* Wertheimer and Descotes recorded no such com plaints following bilateral total dorsal root section and Harris makes no mention of them though the anaesthesia following his bilateral gasserian ganglion injections involve a greater area than is affected by subtotal or differential dorsal root section In our cases some of which have been followed for a number of years eating habits were quickly acquired the patients attended dinner parties without embarrassment and were able to pursue their accustomed occupations within a few weeks after operation

White and Sweet consider bilateral neuralgia a clearcut indica tion for tractotomy *In this condition,* they say, *it should be performed on at least one side* so that the preservation of touch on the tractotomized side will permit normal intake of food which is difficult with total anaesthesia of the mouth Of thirteen trigeminal tractotomies performed by them for idiopathic trigem inal neuralgia two were for bilateral trigeminal neuralgia In one pain was present in all three divisions on the right and in the third division on the left a situation which in our experience presents an ideal distribution of pain for conservative surgery—a total resection on the right sparing the motor followed shortly thereafter by a differential section of the left third division sparing the motor the second and the ophthalmic thus pre serving sensation not only in the ophthalmic division and the cornea but also in the roof of the mouth upper jaw and upper lip Instead bilateral trigeminal tractotomy was done Analgesia was obtained in the right side where all three divisions were affected for twenty four hours on the left seven weeks after operation analgesia was present *only* over the first *division* in which there had been no pain In addition the patient had analgesia of the right fifth cervical segment due to the tractotomy

The second patient had had pain in the second and third divisions for which a left dorsal root section had been done previously by another surgeon with loss of the motor division Because of pain in the right second and third divisions a right trigeminal tractotomy was performed Analgesia was produced in

the ophthalmic division where the patient had had no pain as well as in the second and third divisions and also in the oral pharynx tonsillar region and the external auditory canal areas which are not supplied by the trigeminal nerve except perhaps part of the external auditory canal In addition following the operation the patient experienced hypalgesia of segments L1 S5 in the contralateral lower extremity and burning of the sole of the foot on walking ataxia of the ipsilateral arm and an ataxic gait with lateral propulsion lasting two months There was no return of the paroxysmal facial pain but neurotic symptoms developed raising in the authors minds a question of the original diagnosis

In view of such observations as the foregoing and in consideration of our own favorable results following subtemporal dorsal root section our preference is for selective destruction of fibers by subtotal or differential section which minimizes the sensory loss affords a greater likelihood of permanent relief and avoids the additional and needless neural defects associated with trigeminal tractotomy

CHAPTER XV

SECTION OF THE TRIGEMINAL DORSAL ROOT AT THE PONS

From the time of Hartley's extradural subtemporal approach to the gasserian ganglion that route was universally employed for dorsal root section in trigeminal neuralgia until Dandy (1925) proposed a posterior fossa approach and section of the sensory root of the trigeminal nerve at the pons

Ramonede (1903) a number of years earlier working on a cadaver had proposed a cerebellar approach to the dorsal root through a 3 cm opening in the bone at the junction of the parietal mastoid and temporal sutures His suggestion was to retract gently the cerebellum (the emissary veins though variable and inconstant are so placed that they could be disregarded) and excise a 1 cm segment of the trigeminal root or the surgeon could content himself by simple section of the nerve since union of the ends floating in the cerebrospinal fluid was considered most improbable Perhaps Ramonede suggested a surgeon having especially constructed instruments *ad hoc*, and possessing perfect dexterity should be able to cut the sensory without the motor

In 1917 Doyen recommended division of the trigeminal root between the ganglion and the pons *via* a posterior approach According to this technique the occipital bone is perforated with a 20 mm burr the dura is opened and the cerebellum exposed and cautiously retracted An intracranial endoscope is then introduced above the nervus acousticus showing the trigeminal root about 5 or 6 mm above the acousticus and about 14 or 15 mm beyond it Doyen's special guillotine knife is introduced and its terminal hook passed beneath the trigeminal root which is divided by pressure on the lever (see Fig 69)

The posterior approach to the trigeminal root was first used

by Dollinger (1912) of Budapest In a report before the *Association Française de Chirurgie* in 1908 he commented upon the futility of peripheral nerve sections referred to the excessive bleeding occasionally encountered in operations *via* the subtemporal route and proposed the suboccipital approach as being less vascular Reviewing his experience with the subtemporal operation he stated that the cavernous sinus was opened in almost every case and consequently the severe bleeding which ensued overshadowed the entire operation In twenty five opera

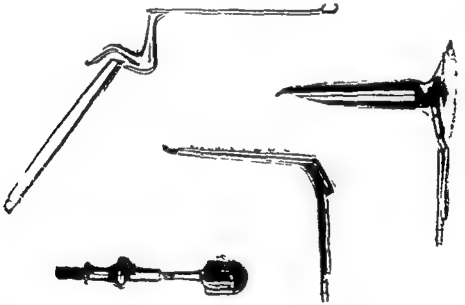


Fig 71 Instruments required in retrogasserian neurectomy at the pons as proposed by Doyen in 1917 Doyen *Surgical Therapeutics* 1917 Courtesy (William Wood) Wilkins and Wilkins Baltimore

tions however he had only one death Nevertheless in three cases in order to avoid serious hemorrhage he refrained from removing the gasserian ganglion and instead exposed the tentorium and extirpated the trigeminal dorsal root beneath the cerebellar hemisphere Thereby he states not only was the excessive bleeding lessened but my patients were cured and an artillery captain returned to his military service However the operation is in no wise less formidable than extirpation of the gasserian ganglion it requires as much experience and as much

anatomical orientation and is only a little easier than the trans temporal method Dollinger believed that trigeminal neuralgia could be permanently cured and that with suitable technique neither operation was overwhelmingly difficult Yet every sur geon who operates knows full well that the procedure is a major one Dollinger held that surgery should be done only as a final resort since as Schloesser had shown alcohol injection would control the pain

Certainly Doyen s technique involves a risk which few neuro surgeons would care to assume should bleeding from one of the emissary veins occur in a field so limited and in which hemorrhage

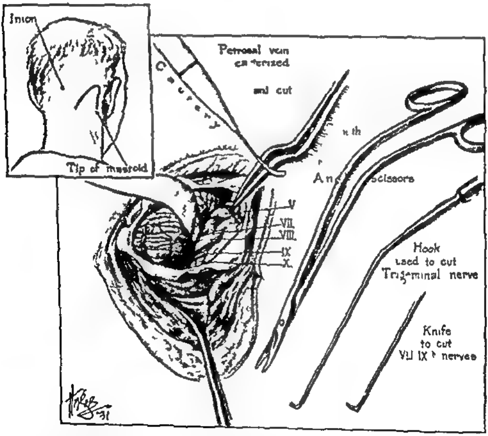


Fig 72 Instruments used by Dandy in dividing the various nerves in the posterior cranial fossa If necessary the petrosal vein may be obliterated by the cautery *This is only occasionally necessary* The sensory root is usually divided with a blunt hook or it may be pinched with the forceps Figure and legend from Dandy *Ann Surg* 1932 Courtesy J B Lippincott Co Philadelphia

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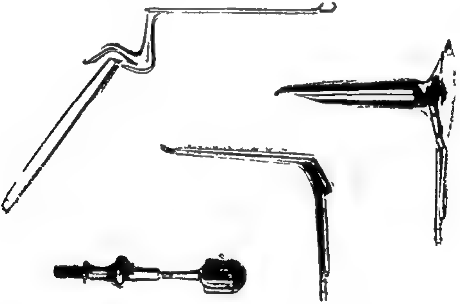

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The cerebellar hemisphere is then elevated with a narrow spatula directed upward and inward The thin membranous covering of the cisterna lateralis which extends the entire length of the posterior fossa and lines the brain stem is opened between the auditory nerve and the tentorium After the collapse of the cisterna lateralis and removal of the loose arachnoid membrane between the auditory nerve and the tentorium the sensory root of the trigeminus stands out sharply in the depth At the incisura tentorii the petrosal vein crosses from the inferior surface of the cerebellum to the petrosal sinus It lies in and is attached to the outer lining of the cisterna lateralis The arachnoid membrane must therefore be cautiously removed from the vein to avoid tearing it

The petrosal vein and the auditory nerve are the two most important landmarks and between them—they are about 1 to 1 5 cm apart—the spatula is introduced The sensory root of the trigeminus is then in full view throughout its course from the tentorium to the pons a span of from 1 to 1 5 cm The sensory root lies probably 1 cm deeper than the petrosal vein A small blunt dissector at an angle with its long shank is passed between the sensory root and the pons in order to free the nerve A small angled knife also on a long flexible shank then follows up the free space between the nerve and the pons and by gentle traction on the blade of the knife the nerve is severed either in part or whole as desired Section of the nerve is usually bloodless ; occasionally a tiny bleeding is suppressed by the application of a moist cotton pledget

The operation is much easier and quicker to perform than the temporal method for the route is bloodless Only a few minutes are usually required to elevate the cerebellum open the cisterna lateralis and aspirate the cerebrospinal fluid and complete the section of the nerve There are times when the petrosal vein causes trouble because of its inconstant position and size Occasionally it may obscure the nerve in part or even almost entirely It is then necessary to retract the vein with the spatula On two occasions the vein was torn by retraction but the bleeding was controlled by packing gently with the moist cotton or by application of a silver clip Recently when the vein has obscured the sensory root or rendered its exposure difficult it has been doubly clipped and divided at once This is made much easier and safer by using flat clips in a long

could not be controlled Even now however the tendency is to use a relatively small occipital opening in order to shorten the operative procedure The limitations thus imposed in a field of such potential dangers can be disastrous

When Dandy published the first account of his procedure he had operated on two patients and observed two advantages (1) the ease of the approach to the sensory root due largely to the bloodless intracranial course of the dorsal root and (2) the seemingly easier preservation of the motor root In his first cases he passed a small hook around the sensory root which was then gently pulled and divided In both cases the motor root was uninjured and could be seen intact through the hiatus in the severed sensory root and lying parallel to behind and along the superior border

The technique subsequently employed by Dandy is as follows

The Operation A somewhat crescent shaped incision is made in the occipital region on the affected side The incision begins near the midline and extends in transverse direction just below the origin of the trapezius muscle Laterally the incision turns sharply downward in a straight line to the tip of the mastoid The trapezius muscle is divided transversely stripped from the occiput and retracted downward and somewhat mesially An area of bone perhaps 4 by 4 cm is removed and two extensions of this central defect are made—one toward the cisterna magna the other toward the mastoid The latter extension must be carefully made so that the utmost room can be obtained Cautiously the bone is nibbled away toward the mastoid cells and the transverse and sigmoid venous sinuses The mastoid cells are of course carefully avoided because of the danger of infection Occasionally they have been opened accidentally, but with no untoward effect The opening however is always covered with a flap of dura which is sutured to the periosteum In the region of the transverse sinus and its junction with the sigmoid sinus the lateral bony extension can be made larger because the mastoid cells usually stop at a lower level This extension is really the most important part of the bony defect for it is from here that the subcerebellar approach is made The dura is then incised in stellate fashion and at once the cisterna magna is sought and opened The release of this fluid provides ample room for exploration

This vein is merely pinched with forceps through which the current is passed to obliterate the vessel The control of the petrosal vein and its branches was really the only element of danger in the operation and this can now be easily and safely overcome if necessary with the cautery As a matter of fact it is only once in about fifteen cases that it is necessary to occlude the petrosal vein for in the remaining cases the sensory root is not at all obscured by this vessel

Third —Suction is now used to evacuate the fluid in the cisterna lateralis this makes it unnecessary to sponge and, therefore it not only saves time but avoids any possible injury to the auditory nerve which lies at a safe distance posteriorly Suction is applied indirectly through a pledget of cotton that is placed in the cisterna lateralis It acts therefore as through a wick

Fourth —Formerly a sharp knife on a long handle was used to divide the sensory root The division of the sensory root is now performed much more easily and safely by using either a blunt hook or by pinching the nerve with the blades of a long narrow forceps It requires very little force to interrupt the nerve fibres

Fifth —The dura is always closed over the entire defect In one of the early cases an intracerebellar haemorrage resulted because of trauma to the cerebellum when post operative vomiting thrust the cerebellum against the sides of the bony defect

The sensory root may be either partially or totally divided by this procedure with equal facility In my experience the operation is far easier to perform than by the temporal route The average time required is perhaps one half hour from the incision to the division of the sensory root though in many cases it has been performed in ten to fifteen minutes This is mentioned not as any great point of merit but because the operative procedure has been frequently criticized as being very difficult and dangerous

The petrosal vein was a potential source of trouble because of its inconstant course and variations in position and size At times it obscures the nerve it may bifurcate or may be double throughout its course It was occasionally torn and this Dandy regarded at first as a dreaded complication though later he

clip holder specially made with the handle bent at right angles to the shaft The petrosal vein has in addition other abnormalities at times it bifurcates again it may be double throughout this part of its course and on two occasions it was absent In two of the earlier cases the auditory nerve was traumatized by the spatula in trying to avoid or retract the petrosal vein In neither of these cases did the hearing return although the nerve was intact In one of these cases the facial nerve also was paralyzed but the function returned three months later Only once has the facial nerve actually been seen at the operation It is usually so well covered by the auditory nerve that it is entirely out of sight Injury to the auditory nerve must be considered a potential danger of the operation It should hardly occur again when one can if necessary so easily dispose of the petrosal vein In a recent case I felt sufficiently secure in this regard to perform the operation despite the fact that the patient was totally deaf in the other ear

On two occasions the posterior surface of the cerebellum has been injured but without any subsequent appreciable disturbance of gait or equilibrium In one of these cases a vein running between the tentorium and the cerebellum was torn when the cerebellum was being cautiously elevated By quickly enlarging the bony defect it was possible to locate and close the bleeding point evacuate the hematoma and proceed with section of the nerve In the other case the cerebellum bulged so tightly despite the release of fluid that the operation could not proceed until a subsequent stage when the bony opening was enlarged to give more room Swelling of the brain is a not uncommon sequel of ether anesthesia

As Dandy's experience increased he made a few technical changes

First—Avertin anaesthesia has been substituted for ether either by inhalation or per rectum This is a great advantage because there is no swelling of the cerebellum as obtains with ether and there is therefore ample room for exposure of the cerebello pontine angle in all cases Furthermore it provides perfectly smooth breathing which rarely follows ether and which is so essential when the sensory root is divided

Second—The electrocautery makes it possible to easily coagulate and divide the petrosal vein should this be necessary

case the presence of such an artery in close relation to the root must be frequently encountered and is an added hazard which certainly is not found in the subtemporal region

To Dandy's own modifications each surgeon has added others to conform with his own technical preferences Hyndman (1938) made several valuable improvements He used a more lateral and superior exposure to permit of a more direct approach to the dorsal root and so placed the skin incision as to exclude the great occipital nerve His opening in the bone was about the size of a fifty cent piece (30 mm) Hyndman also developed a guillotine knife mention of which has been made earlier This is an asset not only in the cerebellar approach but also in differential section *via* the subtemporal With this instrument the fibers selected can be severed more accurately than is possible with a hooked knife or by avulsion since traction on a part of the root may avulse not only the selected fibers but the whole root or additional funiculi may be torn

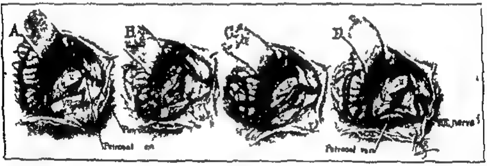

Fig 74 Variations in the course of the petrosal vein The position of this vein is important in making the operation easy or difficult It is sometimes *necessary to divide the vein* between silver clips in order to safely expose the sensory root A usual course B vein bifurcating between the cerebellum and the tentorium C vein running posterior to the trigeminus D vein running along the base of the skull and over the eighth nerve practically obscuring it Figure and legend from Dandy *Arch Surg* 1929 Courtesy American Medical Association Chicago

Walker (1950) places the patient on his side with the head of the table elevated about 15 or 20 degrees using a board under the buttocks to maintain the patient's position with the head slightly flexed A lumbar puncture needle is put in place to permit removal of spinal fluid so as to allow easier exposure of

found it of no concern since the electrocautery and continuous suction have made the operation simple and almost free of risk Yet one of the figures in Dandy's chapter on the brain in Lewis *Surgery* shows a large arterial branch upon or under the sensory root (see Fig 75) Referring to this he commented In many instances the nerve is grooved or bent by the artery This I believe is the cause of tic douloureux If we agree that this is the

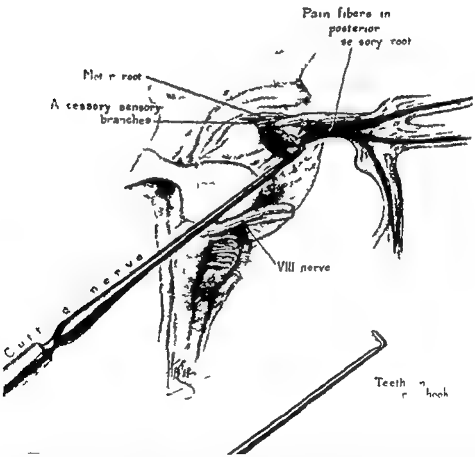

Fig 73 Diagram showing method of partial section of the sensory root From the results of our cases it is our impression that the fibers which are responsible for the pain of tic douloureux in all three branches are included in the posterior half of the sensory root They (represented by the dark lines) concentrate in this part of the sensory root Removal of the bundle does not affect pain induced by sensory stimuli but only the pain of tic douloureux Figure and legend from Dandy *Lewis Walters Practice of Surgery* 1945 Courtesy W F Prior Co Hagerstown

by this step with the possibility of permanent damage Walker Miles and Simpson (1956) have performed differential section of the dorsal root at the pons cutting the inner or outer third or the outer two thirds It would appear from Walker s report that at the pons the segregation of the fibers from each division is not as definite as it is close to the ganglion

In evaluating the relative merits of subtemporal and suboccipital dorsal root section the technical advantages should be considered apart from the physiological From a purely technical standpoint some may prefer the suboccipital operation and in skilled hands the potential dangers would be minimized and safety obtained Some of the advantages are readily acknowledged The motor division can be more surely spared than by the subtemporal route which is a recommendation in bilateral trigeminal neuralgia when the motor division to the muscles of mastication on one side has been destroyed and operation on the opposite side is imperative

The posterior approach also becomes the operation of choice when the region of the gasserian ganglion is involved by carcinoma or other tumor making it impossible to operate successfully *via* the usual subtemporal approach Another obvious advantage as Dandy pointed out is the relief of pain when for one reason or another it is desirable to sever the glossopharyngeal as well as the trigeminal It is possible to divide both nerves at the brain stem almost as easily as either one separately In this event however it may be preferable to resort to tractotomy as has been done successfully in the treatment of these disorders so as to preserve tactile sensation Indeed it is under such circumstances that tractotomy has its greatest usefulness This procedure was not available when Dandy suggested the cerebellar approach for relief of bilateral pain in malignant disease of the tongue throat and pharynx as well as for chronic ulcers and radium burns

In addition to meeting the foregoing indications dorsal root section *via* the posterior fossa has the advantage of avoiding temporary facial paralysis which occasionally occurs with subtemporal exposure though the danger of permanent injury to the facial must be considered

Not everyone will agree with Dandy that the operation is

the cerebellopontine angle care being taken to withdraw fluid *only as required A straight incision of 4 to 5 cm is used 5 cm* posterior to the external auditory meatus a burr hole is made and through this opening the operation is continued Should bleeding occur no attempt is made to find the bleeding vessel which would be hazardous in an opening in the skull giving such limited access Instead the angle is packed with cotton and time allowed for clotting Because of the immediate proximity of the facial and acoustic nerves they would be placed in jeopardy

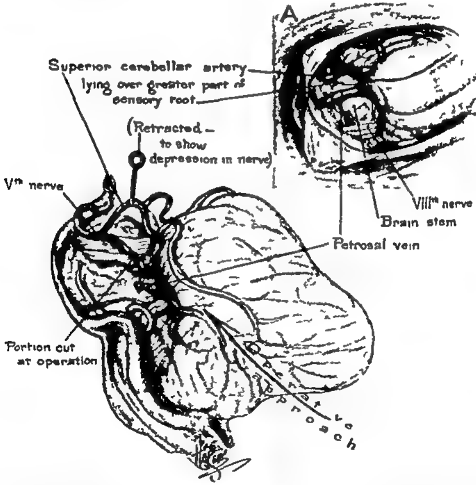

Fig 75 One of the probable causes of trigeminal tic douloureux is an arterial loop which rests either upon the outer surface of the sensory root or on its inner surface elevating it from the brain stem Figure and legend from Dandy *Lewis Walters Practice of Surgery* 1945 Courtesy W F Prior Co Hagerstown

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Not everyone will agree with Dandy that the operation is

much easier and quicker to perform In his skilled hands that may well have been true, but not every operation proceeds smoothly and unforeseen difficulties can arise Bleeding in the posterior fossa for example is a far greater problem than in the subtemporal region In attempts to control it the possibility of damage to adjacent nerves such as the facial and acousticus represents a serious hazard Injury of the facial nerve under these circumstances results in permanent paralysis Furthermore the suboccipital operation is certainly a more serious operation in elderly people, who constitute the majority of patients many of them with degenerative vascular disease and impaired cardiac function While Dandy speaks of the ease and rapidity of the procedure as compared with the subtemporal route it is questionable if this would hold true for most neurosurgeons While the senior author has frequently been able to do a differential dorsal root section in less than twenty minutes from the time of beginning the skin incision until the nerve fibers were cut he doubts if the procedure could often be completed in this time *via* the posterior approach Speed should not be a determining factor

In advocating the suboccipital approach Dandy has referred to a number of disadvantages inherent in the subtemporal operation including damage to the brain and convulsions facial paralysis and keratitis In our experience aphasia hemiplegia or convulsions attributable to the latter procedure are extremely rare In very old people a transient aphasia or weakness may develop lasting a few days but in our series this has never left any permanent disability We have had one patient who had one convulsion and no more Facial paralysis properly treated is of short duration (see Statistics) Keratitis is found in a small percentage if the ophthalmic division is rendered anaesthetic but this would be equally likely to occur with the suboccipital technique if a subtotal resection were not done and the fibers to the cornea not spared Fortunately the ophthalmic is rarely involved and subtotal and differential sections of the dorsal root have consequently greatly reduced the incidence of this complication

The possible presence of unsuspected tumors in the posterior

fossa which may be brought to view and removed in an early stage has been cited as an advantage of approaching the trigeminal root by way of the cerebellum Dandy reported such tumors in 5 per cent of his cases That this high rate of incidence is not generally applicable among patients undergoing operation for trigeminal neuralgia is obvious Had it held true in cases treated by subtemporal dorsal root section it could hardly have failed to appear in the literature since the tumors continuing to grow would in due course give rise to symptoms and eventually require operation No such disproportionate incidence has been recorded

The explanation of Dandy s high figure is presumably to be found in his definition of terms One of his important reasons for using the cerebellar approach for tic douloureux *or* trigeminal neuralgia (he makes a distinction between the two) was that a tumor might be the underlying cause of the pain According to his definition trigeminal neuralgia never displays the paroxysms so characteristic of tic douloureux The pain is steady varying in intensity and lasting for hours or days without remission and even then the freedom from pain is usually incomplete This obviously is not the pain of trigeminal neuralgia but rather that which may be caused by a tumor If then these criteria be accepted as indicative of trigeminal neuralgia a high incidence of tumors would be inevitable in any series This has not been true in our experience Only one patient subsequently came to operation for an angle tumor which *might* have been present at the time of dorsal root section Such a rare incidental finding does not constitute a sufficiently persuasive argument to tip the balance in favor of the cerebellar approach In any event the extremely small opening now being used renders impossible adequate exploration of the posterior fossa

The final word on the significance of tumors as an indication for the suboccipital approach is furnished by Revilla s (1947) report on 757 cases diagnosed as trigeminal neuralgia at Johns Hopkins Hospital from 1925 to 1945 In 473 of these Dandy s operation was performed In twenty four or 5 1 per cent of this number tumors—eighth nerve neurinomas epidermoid cysts or meningiomas—were found in the posterior fossa

By definition in trigeminal neuralgia organic signs are not present and if found negate the diagnosis In this series ten of eleven neurinomas showed associated organic signs In five there was loss of vestibular responses on the side of the pain Mild sensory changes were found in four and in one there was bi lateral papilledema and unilateral deafness Erosion of the porus acousticus was present in three Of the four meningiomas one produced definite organic impairment of vestibular responses and loss of hearing Of nine epidermoid tumors three were associated with organic signs—facial weakness in one nystagmus with di minished caloric and vestibular responses in the second and loss of taste on the anterior two thirds of the tongue in the third

Thus of the twenty four patients with tumor *fourteen* had definite organic signs and consequently would not be considered as having trigeminal neuralgia The ten remaining or 2 1 per cent would have been missed by the subtemporal approach just as tumors arising in the subtemporal region would be overlooked if operation were done by the suboccipital method The choice between a subtemporal and suboccipital approach should not rest on the *possibility* of an unsuspected tumor since this may exist in either region but rather on the merits of the operation in a condition where the age and poor condition of many of the patients must be weighed in the election of a surgical procedure

Since Weisenberg s (1910) case, cited by Dandy and fre quently referred to in the literature as a classical example of a cerebellopontile angle tumor simulating true trigeminal neuralgia is not in accord with our experience it seemed worth while to turn to the original report for details of the neurological findings

The patient was first seen by Weisenberg four years after the onset of pain in the right upper teeth The teeth had been ex tracted and five peripheral operations had been done *in* the infra orbital foramen without relief No other statement is made concerning the onset of the pain or its character We are thus left in ignorance of the all important details of the nature of the complaint and its course during the first three years On Weisen berg s *first* examination a small area of anaesthesia was found at the site of the previous operations *In addition the patient had a leathery feeling over the rest of his face and palsy of the external*

and superior rectus and the inferior oblique muscles of the right eye, supposedly due to the earlier operations (italics are the author s) How this could be possible when the operations were done *in* the infraorbital foramen is not clear While the patient was under Weisenberg s care the inferior dental branch was severed followed by an unsuccessful attempt to remove the gasserian ganglion Due to failure of these measures repeated injections of alcohol were given and the patient was then admitted to another hospital

Up to this time no mention is made of a detailed neurological examination nor is it suggested that any other diagnosis than trigeminal neuralgia had been considered or investigated Following admission to still another hospital on February 13 1907 a further operation was performed and part of the ganglion was removed This afforded complete relief in the trigeminal area but three days later the patient began to complain of pain under the right jaw and in the right side of the throat This pain was constant and was regarded as functional Still no detailed neurological examination is reported and none appears until near the fatal termination of the case when we are told that the reflexes in both legs were present and equal

On reviewing the record of this case it seems that from the beginning attention was focused wholly on trigeminal pain and its treatment At no time so far as the record shows was the question of any other diagnosis raised and this in spite of the fact that when first seen by Weisenberg the patient had a *leathery feeling of the entire face* and *palsy* of the *external and superior rectus and inferior oblique muscles* In view of this apparent disregard of pertinent symptoms it is hardly justifiable to accept this as a classical example of an angle tumor simulating *true* major trigeminal neuralgia as has been repeatedly cited

Dandy s Physiological Concept of the Trigeminal Dorsal Root Dandy s physiological concept of the trigeminal dorsal root at the pons has evoked considerable controversy and few have been able to confirm his conclusions Reporting on eighty eight cases he claimed that after dorsal root section at the pons the cornea showed not a trace of redness nor did it even appear hazy or lusterless The flow of tears was the same on both sides and

no injury to the motor root resulted In his earlier operations the sensory root was totally severed Later when it became evident how much sensory function was carried by a small accessory filament a small fragment of the sensory root itself was deliberately left thereby making it unnecessary to depend on chance accessory fibers Later a larger portion (from one third to one fourth) of the sensory root was left intact after partial radiculotomy By this method almost normal sensation is permanently retained over the whole side of the face even though the pain for which the patient was operated on has been abolished In effect the operation appeared to do little more than cut pain fibers and to produce essentially the same result in the domain of the trigeminal nerve as chordotomy for pain in the extremities In the last twenty cases [of this series of eighty eight operations] partial division of the sensory root has been used exclusively Subsequently it was employed in a series of 500 cases

Commenting on his results Dandy remarked that examination showed such great variability in both the quantity and quality of the retained sensations that one s credulity might well be tested The only uniform result is retention of touch though even this is of varying acuity the most frequent observation was greater sensation over the forehead less over the cheek and still less over the chin The conclusion was that there must be some anatomical feature of the sensory root which has not been recognized A possible explanation was believed to lie in a variation in size—in some cases the sensory root was three times as large as in others—and the fact that rotation of the root up to eighty five degrees had been noted Such great anatomical variations—not observed in the root as seen in the subtemporal approach—could obviously account for variations in the area of sensory loss if partial section were done by way of the posterior fossa but not of course for dissociated sensory loss

In subtotal resection at the pons Dandy retained the most anterior fibers believing that the pain fibers were located in the *posterior part of the root His proposals concerning dissociation* within the sensory root by destruction of a third or a fourth of the sensory fibers without loss of all modalities of sensation

in the area served by the severed fibers has raised a number of problems It has not been possible to confirm his statement that when that proportion of fibers of the dorsal root have been destroyed sensation approaching normal is retained over the entire domain of the trigeminus irrespective of the branch involved in the pain and again that only pain fibers are sacrificed and all forms of sensation are retained Nor have others been able to agree that he has offered evidence that the gasserian ganglion mediates a definite function which in large degree modifies the afferent impressions en route to the brain Such a concept involving as it does a new physiological aspect of the gasserian ganglion if applied to all spinal and cranial ganglia derived from the ganglionic crest would endow them with functions heretofore unknown and demonstrated in none of the other afferent ganglia of the cerebrospinal axis

According to Ranson just before a dorsal root enters the cord the unmyelinated fibers separate from the myelinated and arrange themselves at the periphery of each small radicle into which the roots are divided In some rootlets these unmyelinated fibers form a thin peripheral zone surrounding the more centrally placed myelinated fibers In a discussion before the Chicago Neurological Society March 19 1931 in reply to a question by Bailey Ranson expressed the opinion that it seems possible that these fibers (mediating pain) would be situated at the lower border of the nerve as it enters the pons which is just where Dandy cuts and it would not surprise me if by making a section at this border of the nerve close to the pons one would abolish sensibility to pain in the face But as I understand it Dandy does not claim that he abolishes sensibility to pain in the face but merely cures the trigeminal neuralgia That I do not understand

Windle (1926) found the small myelinated and non myelinated fibers which it is agreed transmit pain impulses to lie along the periphery of the root rather than in the center whereas Sjoqvist using the fiber analysis method found that the smaller fibers (3 microns) were scattered throughout the root more especially in the upper portion—namely that part which Dandy was careful to avoid Yet Dandy held that it was predominantly the pain fibers which were destroyed by his operation The

dominance of pain fibers in the ophthalmic Sjoqvist thought might be due to the fact that the cornea is supplied only with these fibers lacking tactile sensation

Davis and Haven (1933) have shown that there is no topographical arrangement of the fibers of the root on a functional basis and no physiological basis by which pain fibers can be destroyed without destruction of other modalities They have further demonstrated that there is no evidence to support the view that section of the sensory root near the pons will abolish trigeminal pain without definite loss of sensation of all forms The experience of most neurosurgeons is in accord with this view Davis and Haven also demonstrated that when the root was sectioned near the pons at the location described by Dandy degeneration occurred in the ventral portion of the descending trigeminal root exactly similar to that which ensues when the ophthalmic division is cut near the ganglion However the arrangement of the fibers in the dorsal root near the ganglion follows fairly closely though not precisely the three divisions of the trigeminal nerve—the outer third derived from the mandibular the middle third from the maxillary and the inner third from the ophthalmic While it is convenient to speak of thirds in this connection more accurate figures would be 45 per cent (from the mandibular) 30 per cent (from the maxillary) and 25 per cent (from the ophthalmic) The morphological studies of Frazier and Whitehead (1925) show clearly the arrangement of the fibers close to the gasserian ganglion

While interlacing of the fibers can be seen in the dorsal root it does not follow that physiological rearrangement of the fibers has taken place Differential and subtotal sections of the root in a large series confirm in general both an anatomical and physiological arrangement at least close to the ganglion

To attempt to explain the sensory findings Dandy advanced the view that there were accessory dorsal root fibers but this has not been corroborated by others In Lewis and Dandy s (1930) study of taste Dandy refers to twenty five patients on whom he did *presumably* total trigeminal section (at the pons) These are not included in this group because sensation in varying degrees has been retained The preservation of sensation is not

due as might be reasoned to subtotal section of the sensory root but to variable adjacent accessory fibers which retain the sensory function There are no accessory rootlets in the subtemporal exposure of the trigeminal dorsal root though it is of course possible with either route for funiculi to escape section A study of Dandy s illustrations suggests that these so called accessory rootlets may be part of the dorsal root separated from the main root in the process of withdrawing one fourth to one third of the root fibers for section In any event accessory sensory rootlets have not been anatomically established The entry zone of the trigeminal root due to extension of the glia into the root is a relatively solid unit the fibers do not enter the brain stem by separate rootlets as occurs in the spinal cord

Dandy also considered the afferent fibers in the motor root as a possible explanation for the retention of sensation and rightly concluded that were this hypothesis accepted it could not account for retained sensation in the ophthalmic or the maxillary since the motor root blends only with the mandibular whereas the retained sensation remained primarily in the ophthalmic

To bring together in more concise form Dandy s views his own conclusions may be quoted

> 1 A new operative attack on the sensory root of the trigeminus is presented for the cure of trigeminal tic douloureux The sensory root is reached at the pons through a bloodless path beneath the cerebellum
>
> 2 The sensory root can be divided either partially or totally At first total division of the sensory root was performed Gradually it was found that by partial section of the root the pain is cured and at the same time the sensation to the entire domain of the fifth nerve is little disturbed
>
> 3 Partial section of the sensory root at the pons is now advocated exclusively
>
> 4 The advantages of partial section of the sensory root by the route here proposed are
>
> (a) Immediate postoperative corneal disturbances are uniformly absent
>
> (b) The motor root is always preserved

(c) Sensation approaching the normal is retained over the entire domain of the trigeminus irrespective of the branch involved in the pain

(d) The corneal reflex is usually preserved

(e) The approach is bloodless after the dura has been exposed

(f) The operation is much easier and quicker to perform

5 The operation is in effect essentially a chordotomy in that only pain fibers are sacrificed and all forms of sensation are retained

6 Observations herein described deny the hypothesis that the peripheral branches of the trigeminus are accurately represented by subdivisions of the sensory root

7 Some postoperative sensory observations suggest that there are separate nerve fibers for various types of sensation

8 Pain fibers appear to travel separately and to be located exclusively in the posterior part of the sensory root (in cross section)

9 Even when the sensory root is totally divided varying degrees of sensation are retained in the face At times this sensation approaches the normal This is due to the fact that accessory sensory branches usually accompany the motor root and later join the sensory root When the accessory branches are absent anesthesia of the face is complete

10 The accessory branches of the sensory root apparently never contain pain fibers nor are pain fibers brought to them by anastomoses with the fibers of the sensory root

11 The motor root is always preserved because it is at a safe distance from the sensory root

12 Bilateral tic douloureux can be cured at a single operation by this method because the motor roots are not injured Two patients have been cured by the bilateral operation

13 Certain facts seem to indicate that postoperative keratitis is due to trauma of the gasserian ganglion or of the sensory root—traumatic neuritis

14 Deep sensation to the face is carried through the trigeminal nerve and not the facial

15 Vasomotor changes do not develop when the fifth nerve is divided

16 Lacrimation continues after division of the fifth nerve

17 Facial paralysis results in the temporal approach because the geniculate ganglion is injured either directly or by tearing the superficial petrosal nerves These nerves are not injured by the cerebellar approach

18 Occasionally tumors in the cerebellopontile angle cause tic douloureux By this approach they will be disclosed The chances of a successful removal are enhanced because the tumor is found earlier By the temporal route these tumors would be missed In the series described one (unsuspected) tumor was found and successfully removed Two aneurysms of the basilar artery—presumably not having any bearing on the neuralgia—were found at operation

19 When malignant tumors invade the gasserian ganglion relief cannot be obtained by dividing the sensory root by the temporal route The cerebellar route is indispensable in such cases

In the light of divergent experience a critical review of these comments seems warranted Exceptions must certainly be taken to some of the conclusions Taking them up in order we believe that the following statements are justified

1 Not everyone will agree that the approach to the sensory root at the pons is bloodless

2 The sensory root may be partially or totally divided by *either the subtemporal or suboccipital approach* The sensory disturbance is for all modalities in proportion to the number of fibers severed

3 Partial section though it may be done at the pons can be done with greater assurance in the subtemporal region where the fiber arrangement is more constant both anatomically and physiologically

4 The advantages of partial section of the sensory root are available by either the subtemporal route or at the pons

(*a*) Immediate postoperative corneal disturbances are uniformly absent if sensation in the cornea is preserved by whichever route the operation is done

(*b*) The motor division is more surely spared with the suboccipital operation but can be preserved also in a large percentage of cases in which the subtemporal route is used

(*c*) Sensation is lost in proportion to the number of fibers severed in the division to which the fibers were destined

(*d*) The corneal reflex is retained by whichever route the dorsal root is sectioned providing sensation in the cornea is preserved

(*e*) The approach can be bloodless by either route depending upon the skill with which the middle meningeal artery—and in the posterior fossa the petrosal vein— is handled Furthermore large vessels as pictured by Dandy indenting and obscuring the root are not found in the subtemporal approach Bleeding in the posterior fossa can be disastrous In our opinion the subtemporal is much easier quicker and safer

5 The operation is not in effect essentially a chordotomy in that only pain fibers are sacrificed

6 Experience with section of the dorsal root in the subtemporal region demonstrates that in that region the peripheral branches are fairly accurately represented by subdivisions in the root

7 Postoperative sensory observations indicate that there are no separate nerve fibers within the dorsal root for various types of sensation which can be severed without destroying all modalities supplied by them

8 In the subtemporal region at least no segregation of pain fibers is found in the posterior part of the sensory root the lateral or posterior fibers supply the mandibular area Pain fibers do not travel separately

9 When the sensory root is *totally* divided all modalities of sensation are lost

10 There are no visible accessory branches to be seen in the subtemporal region and it has not been shown at autopsy that these exist in the posterior fossa

11 The motor root is not *always* preserved but it can be saved in a high percentage of cases See 4 (*b*), above

12 While simultaneous bilateral trigeminal neuralgia can be cured by a single operation *via* the posterior fossa which could not be done by the subtemporal approach, the wisdom of doing the operation in one stage is doubtful Furthermore *simultaneous* bilateral trigeminal neuralgia is *extremely* rare—far rarer than involvement of one side followed at a later period by involvement of the opposite side

13 Certain facts tend to show that postoperative keratitis is due to trauma to the insensitive cornea and is not a traumatic neuritis

14 Since in Dandy's patients trigeminal sensation was in large measure intact it is not clear on what basis the assumption was made that deep sensation is carried by the trigeminal nerve

15 Vasomotor changes by either route are minimal

16 Lacrimation continues after division of the fifth nerve depending upon the number of fibers severed

17 It is true that facial paralysis does develop in the temporal approach because the geniculate ganglion is injured rarely directly or by tearing the great superficial petrosal nerve These structures are not injured by the cerebellar approach However the facial paralysis is temporary not permanent as it may be if the facial nerve is injured in the posterior fossa

18 Tumors in the cerebellopontile angle cannot be disclosed by the subtemporal operation but middle fossa tumors can be found by the subtemporal route Their frequency however is questionable Their subsequent incidence in a large series of subtemporal dorsal root sections has not been reported

19 When malignant tumors invade the gasserian ganglion relief cannot be obtained by the subtemporal route but can be secured by the cerebellar route Such tumors constitute an outstanding indication for the latter approach

In a sense it is unfortunate that the physiological implications of the posterior approach to the trigeminal dorsal root have been the subject of so much controversy since this has tended to obscure the value of a procedure which has added greatly to the armamentarium of the neurosurgeon

(a) Immediate postoperative corneal disturbances are uniformly absent if sensation in the cornea is preserved by whichever route the operation is done

(b) The motor division is more surely spared with the suboccipital operation but can be preserved also in a large percentage of cases in which the subtemporal route is used

(c) Sensation is lost in proportion to the number of fibers severed in the division to which the fibers were destined

(d) The corneal reflex is retained by whichever route the dorsal root is sectioned providing sensation in the cornea is preserved

(e) The approach can be bloodless by either route depending upon the skill with which the middle meningeal artery—and in the posterior fossa the petrosal vein— is handled Furthermore, large vessels as pictured by Dandy indenting and obscuring the root are not found in the subtemporal approach Bleeding in the posterior fossa can be disastrous In our opinion the subtemporal is much easier quicker and safer

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10 There are no visible accessory branches to be seen in the subtemporal region and it has not been shown at autopsy that these exist in the posterior fossa

11 The motor root is not *always* preserved but it can be saved in a high percentage of cases See 1 *(b)* above

was first investigated by Bregman (1892) who studied degenerations within the tract after differential section of the trigeminal nerve in rabbits He found that the ophthalmic maxillary, and mandibular fibers terminate at different levels within the brain stem the ophthalmic at the second cervical segment the mandibular at the upper part of the medulla and the maxillary at an intermediate level though a few of these last may descend as far as the ophthalmic Wallenberg (1896) not only confirmed these conclusions experimentally but (1895) as a result of Bregman s work reasoned that the syndrome consisting of dissociated loss of sensation of one half the face deviation of the tongue paralysis of the vocal cords miosis enophthalmos ptosis loss of pain and temperature sense in the opposite half of the body and hemiataxia was due to a lesion in the brain stem resulting from occlusion of the posterior inferior cerebellar artery which is the principal source of blood supply to the area of the medulla through which the trigeminal fibers pass He was unable however to offer proof of his thesis until 1901 when autopsy revealed a thrombus obstructing the artery in his patient

The first case of occlusion of the posterior cerebellar artery to be reported with autopsy and pathologic sections was presented by Hun (1897) under the descriptive title Analgesia Thermic Anaesthesia and Ataxia Resulting from Foci of Softening in the Medulla Oblongata and Cerebellum Due to Occlusion of the Left Inferior Posterior Cerebellar Artery A Study of the Course of the Sensory and Conducting Tracts in the Medulla Oblongata Though this report did not appear until 1897 Hun s patient had first been seen in 1881 He died in 1892 and Van Gieson completed his pathologic study of the case in 1893 (see Fig 74) This showed softening at the mid level of the inferior olivary nucleus extending about 7 or 8 mm From these observations Hun reasoned that the descending trigeminal nucleus mediated pain and temperature for one half of the face since his patient showed dissociated sensory loss He rightly concluded that this case made it certain that the fibers of the fifth nerve after they have left the gasserian ganglion possess distinct functions and that the fibers conveying impulses for thermic and painful perception are all collected together in the descending root of the

CHAPTER XVI

DESCENDING TRIGEMINAL TRACTOTOMY NUCLEO TRACTOTOMY

The original suggestion for section of the descending trigeminal tract was made by W. H. Riley (1927) in a discussion of one of Frazier's papers on subtotal resection. He asked if Dr. Frazier or any other brain surgeon had considered the advisability of dividing the descending root of the fifth nerve which carries sensation of pain and temperature only and leaving the function of tactile sense intact. To this Frazier replied: The suggestion of operating on one of the two roots of the branches of the fifth root is very ingenious, but I do not think that it is altogether practicable. There is no doubt that it would add very considerably to the risk of operation, and the first question which every patient with trigeminal neuralgia asks when the question of operation is approached is whether there is any risk. Subsequently Kuntz in a discussion of a paper by Ranson (1931) on cutaneous fibers and sensory conduction presented before the New York Neurological Society, January 13, 1931, suggested that if it were not too difficult, certain changes might be made in the usual procedure of dorsal root section to convert it into an operation designed to cut the descending fibers of the trigeminal tract. As to this possibility, Stookey in discussing Ranson's paper pointed out that while a suboccipital craniotomy with a transverse section into the descending fifth tract might be done, it would be an undertaking of considerable magnitude, especially since the patients in whom dorsal root section is indicated are frequently advanced in years. Ranson also agreed that, though it would probably be possible to relieve trigeminal neuralgia by section of the spinal fifth tract, this would appear to be a more serious operation than section of the sensory root.

The detailed arrangement of the descending trigeminal tract

sensory fibers of the trigeminal nerve bifurcate the smaller branch of each entering the descending tract to carry pain and probably temperature sensation while the larger ascends to the main sensory nucleus to mediate tactile sensation This interpretation presumed that the same fiber carries pain temperature and tactile impulses—a presumption supported by the work of Forbes and Gregg (1915) and Lucas (1917)— the three modalities having different synapse frequencies Thus touch would be able to pass its synapse in the main sensory nucleus while pain and temperature entering by the same fiber would have their synapse in the descending trigeminal nucleus

Windle (1926) working in Ranson s laboratory showed that 42 per cent of the fibers of the trigeminal in the pig embryo were non medullated and that these fibers did not bifurcate but descended directly into the descending root to terminate in the descending trigeminal nucleus He noted that the fibers which bifurcate tend to bend upward before bifurcation explaining this on the basis of the neurobiotactic pull of the main sensory nucleus while the non medullated non bifurcating fibers did not present this upward thrust

The physiological studies of Gasser and Erlanger (1927) and Adrian and Zotterman (1926) established that pain and temperature were carried by the small fine fibers generally under 4 μ whereas tactile sensation was carried by the large fibers with a relative diameter of more than 6 μ

While these studies and fiber measurements contributed much to the fundamental physiological basis of conduction of pain temperature and tactile sensation from a purely clinical and practical standpoint the conclusion reached by Hun has not been altered namely that the descending trigeminal tract and nucleus are concerned with pain and temperature while the main sensory nucleus receives tactile impulses

Thus the anatomical clinical pathological and physiological basis was well established for the assumption that severance of the descending tract would be followed by loss of pain and temperature sense but that tactile sense would be retained Obviously if this could be successfully accomplished *without* significant associated disturbances of the neighboring structures

fifth nerve while all fibers conveying impulses for tactile per ceptions probably pass to the sensory trigeminal nucleus lying in the floor of the fourth ventricle It accords well with our physio logical conceptions that the descending root which has a long course is in such close proximity to many motor nuclei and is evidently well fitted to convey impulses for reflex acts

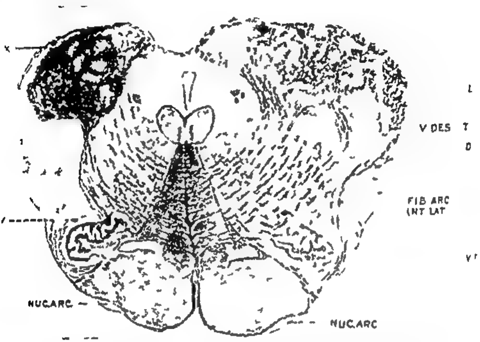

Fig 76 Figure representing a section through the medulla oblongata at a level near the caudal end of the fourth ventricle showing the undegener ated tracts of Flechsig and Gowers and degenerations in the lateral portion of the formatio reticularis on the left side in the descending root of the left fifth nerve surrounding both olives and to a lesser degree in the right anterior pyramid Figure and legend from Hun H *New York Medical Journal* 1897 Courtesy D Appleton and Co New York

Further detailed studies of the occlusion of the posterior in ferior cerebellar artery with special reference to the function of the descending trigeminal tract were made by Gerard (1923) Stopford (1925) and Smyth (1939) The work of Gerard and Stopford confirmed the essential conclusions expressed by Hun Stopford called attention to variations in the syndrome Gerard collected from the literature a considerable number of cases and supplemented her clinical observations by experimental studies on cats leading her to the conclusion that most if not all of the

Evipan is given intravenously if this be the anesthetic chosen The arachnoid is then stripped from the cerebellar tonsils and one of them is cautiously elevated by means of a soft brain spatula The tonsil is gently loosened by blunt division of the tiny pial adhesions to the medulla The tonsil must be handled very gently in order to avoid traumatism and subsequent edema The exists of the cranial nerves then come in view up to the group formed by the acoustic and facial nerves One identifies the eleventh tenth and twelfth nerves and also the eminentia olivaris and restiform body On elevating the tonsil the fourth ventricle should be opened to identify its inferior end Under the cranial nerves the vertebral artery is seen and may usually be followed up to its entrance in the basilar artery A loop of the posterior inferior cerebellar artery generally lies on the ventral surface of the tonsil This loop sometimes may be left in place at times it is expedient to elevate it together with

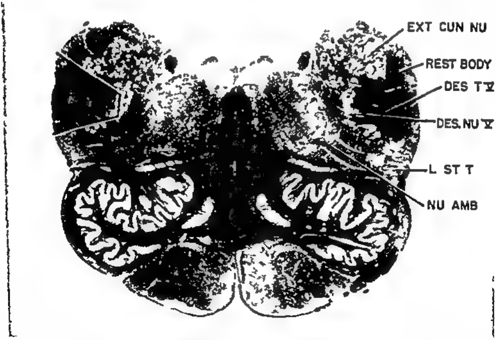

Fig 77 Microphotograph of medulla junction between middle and lower third of inferior olive mag [illegible] X indicating level of tractotomy first proposed by Sjoqvist 1938 Incision shown at left 3 3 5 mm deep Neural structures indicated on right Ext Cun Nu External cuneate nucleus Rest body Restiform body Des T V Descending tract of trigeminal nerve Des Nu V Descending nucleus of trigeminal nerve L ST T Lateral spinothalamic tract Nu Amb Nucleus ambiguus

and without too great an operative risk especially in the older age group the treatment of trigeminal neuralgia would be advanced materially, as was originally pointed out by Riley and Kuntz

It remained for Sjoqvist (1938) to propose a technique looking to the accomplishment of this end His procedure was as follows

Anesthesia If the patient is given morphin and luminal previously the operation may well be performed under local anesthesia until the incision of the dura The entrance of air into the subarachnoidal space brings about a frontal head ache and contact to the cranial nerves may be painful which renders general anesthesia desirable during this stage The actual section of the tract is extremely painful In performing suboccipital puncture contact to the lateral part of the cervical cord may sometimes be unavoidable and is immediately fol lowed by sudden severe pain in half of the face Local anes thesia combined with a short Sodium Evipan sleep during the intradural stage of the operation therefore should be the method of choice Some cases also were operated upon under Avertin anesthesia The choice of anesthesia may depend on the personal experience of the operator

Incision and approach The incision is the usual one for unilateral cerebellar exposure It should surpass the mid line a few centimeters in order to allow removal of the bony posterior margin of the foramen magnum After the muscles have been dissected from the occipital bone a burr hole is made and the bone is rongeured away over one cerebellar hemisphere It is unnecessary to remove the bone in the direction upwards and laterally to the same extent as on ex posure of the cerebellopontile angle but the posterior margin of the foramen magnum must be removed in order to secure *sufficient room for a precise orientation In the first cases* the arch of the atlas was resected also This however is unnecessary but the dura should be split in the mid line down to the atlas Ample exposure still is of great importance for the safe per formance of the operation and it is preferable to make the opening in the bone too large rather than too small

The dura is incised in stellate fashion and split in the mid line down to the atlas the arachnoid is torn and the cisterna magna emptied by the sucker At this stage Sodium

closure of the wound The intervention is then completed as a routine cerebellar operation The dura is stitched to the periosteum and the wound closed in layers without drainage Section of the bulbospinal fifth tract may easily be combined with exploration of the cerebello pontile angle

Reporting on nine cases of tractotomy at the level he suggested Sjoqvist (1938) stated that : the most important details of the operative technique are ample exposure and precise orientation It these prerequisites are not fulfilled the vagus rootlets may be injured with a resultant unilateral *recurrent nerve paresis which is the one single complication of importance in connection with this operation* (italics are the author s)

It was felt by the senior author however that intervention at this level endangered important adjacent neural structures such as the restiform the spinothalamic tract the olivo-cerebellar fibers from the opposite superior olive and the nucleus ambiguous of the vagus He therefore believed the procedure to be ill advised and declined to operate at this level for relief of trigeminal pain when a far safer route the subtemporal had proved eminently satisfactory This conclusion was subsequently reached by others who undertook the operation Olivecrona in whose clinic it had first been done abandoned it but not until he had performed it forty times Grant likewise discarded the procedure and ten years later Sjoqvist (1948) himself stated I realized *very soon* that an incision at such a high level very rarely is feasible and involves danger of damaging the spinocerebellar fibers in the inferior cerebellar peduncle a conclusion which should have been obvious from the beginning But even though it was found very soon that the operation was rarely feasible Sjoqvist s retraction was delayed for a decade!

Because of the unfavorable experiences following Sjoqvist s tractotomy attempts were made independently by Grant and Weinberger (1941) and by Olivecrona (1942) to section the descending tract at a lower and somewhat safer level They selected a point near the obex operating 2 to 4 mm below or slightly above it The existing knowledge at that time of the finer anatomy of the descending trigeminal tract would have led to the conclusion that only the caudal end would have been reached

the tonsil In all cases it is of course imperative to avoid lesion of this artery On exposing the medulla the root filaments of the tenth nerve must be handled very carefully The safest thing is not to touch them at all nor will this be necessary if ample exposure is made

If the operating table is designed to be rotated around its length axis it is advisable to rotate it a little towards the opposite side to get better view of the lateral surface of the medulla When orientation has become completely clear the point of incision is chosen It is situated immediately caudally to the lowest vagus filaments and a few millimeters dorsally to them At this point the spinal tract is no more covered by the restiform body The level generally corresponds to the border *between the middle and inferior two thirds of the eminentia* olivaris In a previous paper the author suggested that one might on occasion be able to make the incision at a level be tween the superior two thirds of the eminentia olivaris This would very rarely be possible and involves risk to the caudal vagus rootlets Neither is it necessary to make the incision more cranially than at the midst of the inferior olive This corre sponds to a level 8 10 mm cranially to the inferior end of the fourth ventricle

The incision which is made with a very sharp narrow bladed knife with a long straight handle should be 3 to 4 mm long and should be carried out at right angles to the axis of the medulla to a depth of 3 to 3 5 mm It starts immediately laterally to the dorsal nuclei and extends downwards to one millimeter dorsally to the entrance of the vagus rootlets On a square section the incision has the shape of a rhombus The point of incision is not easy to choose and it is advisable to prick a straight needle through a formaline fixed preparation of a medulla oblongata along the bulbospinal fifth nucleus which easily may be identified even without staining and to use this preparation as a guide when first performing the operation On choosing the point of incision one ought to keep away from the visible pial vessels

The moment at which the tract is struck by the incision is usually signalled by some pain reaction of the patient even when general anesthesia is deep The bleeding from the in cision is minimal and ceases within short of its own accord All oozing from the incision should have subsided before

plain that sections to reach the fibers derived from the mandibular division would need to be made at a higher level than to reach those from the maxillary or ophthalmic division Further more the ophthalmic fibers occupy a more ventral position within the tract than the maxillary or mandibular the mandibular lying dorsal and the maxillary between the two The ventral position of the ophthalmic division is found throughout the animal scale from fish to man This commonly accepted view has not gone unchallenged however Raney in 1950 advanced a concept of the topographical relation of the fibers which is quite the reverse In view of the known anatomy and the position of the fibers in the comparative scale this hypothesis requires confirmation before it can be accepted

It is doubtful whether conclusions concerning the finer points of the inner topographical arrangement of the fibers can be de

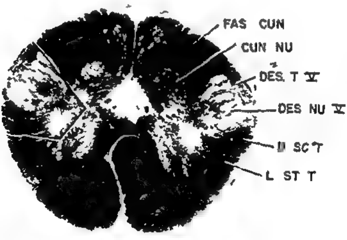

Fig 79 Microphotograph low medulla junction between medulla and spinal cord mag 7 5 X Incision at left 4 5 mm deep Neural structure indicated on right Fas Cun Fasciculus cuneatus Nu Cun Nucleus Cuneatus Des T V Descending tract of trigeminal nerve Des Nu V Descending nucleus of trigeminal nerve D SC T Dorsal spinocerebellar tract L ST T Lateral spinothalamic tract

by an incision at this level leaving intact the major portion of the descending fibers so that degeneration of only the most distal portion caudal to the operative site could take place

Anatomical Background of Tractotomy In order to evaluate fully the anatomical significance of tractotomy at the level originally suggested the detailed anatomy of the descending trigeminal tract and its relations must be studied The fibers carrying pain and temperature pass downward from the entrance of the trigeminal root in the pons through the medulla to the level of the second cervical segment Within the brain stem the fibers from the ophthalmic division descend giving off collaterals to the nucleus as far as the second cervical segment The maxillary division does not reach quite so far and the mandibular has a still shorter course Thus the constituent fibers within the tract vary according to the level studied From what was known of the detailed structure of the descending trigeminal tract it was thus

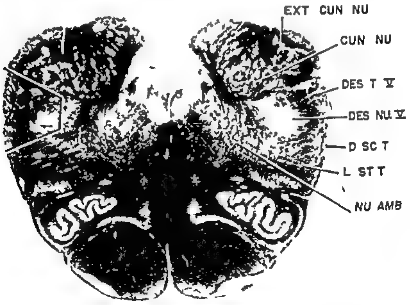

Fig 78 Microphotograph level of obex mag 8 5 × Incision shown at left 2 2 5 mm deep Neural structure indicated on right Ext Cun Nu External cuneate nucleus Cun Nu Nucleus cuneatus Des T V Descending tract of trigeminal nerve Des Nu V Descending nucleus of trigeminal nerve D SC T Dorsal spinocerebellar tract L ST T Lateral spinothalamic tract Nu Amb Nucleus ambiguous

plain that sections to reach the fibers derived from the mandibular division would need to be made at a higher level than to reach those from the maxillary or ophthalmic division Furthermore the ophthalmic fibers occupy a more ventral position within the tract than the maxillary or mandibular the mandibular lying dorsal and the maxillary between the two The ventral position of the ophthalmic division is found throughout the animal scale from fish to man This commonly accepted view has not gone unchallenged however Raney in 1950 advanced a concept of the topographical relation of the fibers which is quite the reverse In view of the known anatomy and the position of the fibers in the comparative scale this hypothesis requires confirmation before it can be accepted

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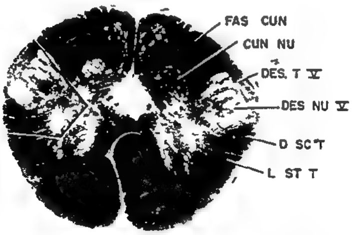

Fig 79 Microphotograph low medulla junction between medulla and spinal cord mag 7 5 × Incision at left 4 5 mm deep Neural structure indicated on right Fas Cun Fasciculus cuneatus Nu Cun Nucleus Cuneatus Des T V Descending tract of trigeminal nerve Des Nu V Descending nucleus of trigeminal nerve D SC T Dorsal spinocerebellar tract L ST T Lateral spinothalamic tract

duced from operative material without precise information as to the incision—its exact location and depth—followed by careful serial pathological sections of the tract While surmises have been made on clinical grounds these cannot be accepted as final

With the anatomical data available at the time of the early development of tractotomy concerning the function of the descending tract and its nucleus, no sound basis in neuroanatomy or physiology could be advanced to warrant section of the most caudal part of the tract at the junction of the medulla and cervical cord leaving intact the major portion of the fibers presumably still transmitting pain temperature and crude tactile sensation Tractotomy at this lower level for relief of trigeminal pain was thus without physiological or anatomical basis Furthermore it carried with it the likelihood of serious associated neurological deficits not incident to subtemporal dorsal root section

Autopsy on one of Grant's patients casts doubt on the known anatomical relationship of the fibers of the trigeminal tract A section in the tract slightly below the obex had been made in May 1939 producing analgesia in the trigeminal area At autopsy the following January, the incision was found to have been made 8 mm below the obex On this basis Grant *et al* advanced the concept that analgesia could be obtained at a lower level than had heretofore been considered possible though this was contrary to all neuroanatomical data as far as the maxillary and mandibular fibers were concerned Whether the arrangement in this case was abnormal or whether the observation was indicative of a more fundamental concept remained to be determined In any event Grant modified his technique placing the incision 6 to 8 mm caudal to the obex in future cases

The recent work of Olszewski and Baxter (1954) has thrown new light on the descending trigeminal nucleus in the human brain stem which has been confirmed in the comparative series by the careful work of Crosby and Yoss (1954) Olszewski and Baxter established the existence of division of the descending trigeminal nucleus into three parts the nucleus tractus spinalis caudalis representing the rostrad continuation of the spinal dorsal horn apical gray which extends approximately 13 mm to the

middle third of the inferior olive, the nucleus tractus spinalis interpolaris extending from the upper border of the caudalis 6 mm through the middle third of the inferior olive and the nucleus tractus spinalis oralis (rostralis) extending approximately 8 mm from the level of the upper third of the olive to become continuous with the main sensory nucleus These three divisions present distinct histologic differences

Histologically the caudal nucleus is of essentially the same structure as the dorsal horn of the cervical spinal cord having three subdivisions the gelatinous which corresponds with the gelatinous substance of Rolando the zonalis corresponding with the posterior marginal cells and the magnocellularis with the cells of the proprius of the posterior horn Not only do the two structures resemble each other in their histologic features but they presumably serve the same function in the transmission of pain temperature and crude sensation The interpolaris and oralis are distinctly different histologically and their precise function has not yet been established It is agreed however that the main sensory nucleus mediates tactile discrimination

Crosby and Yoss believed that if this division of the trigeminal descending tract and nuclei into component parts in the human brain stem as described were basic it should be possible to trace it in the vertebrate series In cyclostomes two nuclei are found one at the entry zone which represents the primordial chief sensory nucleus and one at the caudal end where the descending tract passes into the dorsal horn of the cervical cord without any definite differentiation In amphibians at best a primordial sensory nucleus exists and a group at the caudal end which corresponds to the caudalis of the cyclostomes In reptiles a well differentiated chief sensory nucleus appears the descending nucleus follows the shape of the descending tract but can be divided into a nucleus oralis and caudalis In birds the division into nucleus oralis and caudalis is also seen with a beginning differentiation of oralis into oralis and interpolaris The nucleus caudalis extends into the cervical cord and in mammals the differentiation into chief sensory nucleus nucleus oralis interpolaris and caudalis is definite Thus Crosby and Yoss s comparative study confirms the division found in man by Olszewski and Baxter

These studies suggest an anatomic basis for tractotomy at the obex, or slightly lower with the expectation that not only the ophthalmic but also the maxillary and mandibular fibers may be included However, further clinical studies correlated with serial brain stem sections are desirable

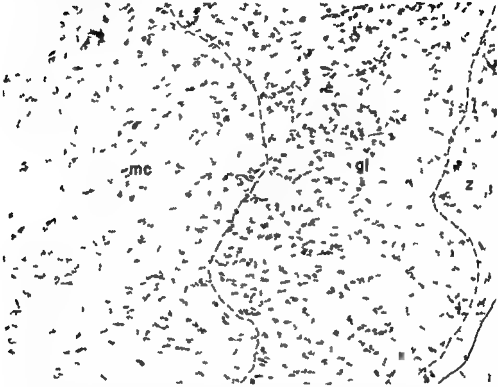

Fig 80 Microphotograph of nucleus tractus spinalis trigemini caudalis mag 150 × Note the subdivision into subnuclei zonalis (z) gelatinous (gl) and magnocellularis (mc) Figure and legend from Olszewski and Baxter *Cytoarchitecture of the Human Brain Stem* 1954 Courtesy S Karger Basel and J P Lippincott Philadelphia

Anaesthesia Olivecrona preferred to operate under local anaesthesia since this permits control of the level and extent of the incision by tests of facial sensibility as the operation procedes and Falconer (1949) was in agreement that this is one point essential to the success of the procedure But while this assures more certain results it has the great drawback that section into the tract is very painful and the patient may move enough to change the direction and depth of the incision A number of surgeons there fore prefer a general anaesthetic though if a local can be toler ated the advantages are considerable

Position The position of the patient must be carefully considered The upright position minimizes bleeding simplifies the operative exposure and makes identification of the landmarks easier In older patients however the loss of cerebrospinal fluid through opening of the basal cisternus with decrease in intra

Fig 81 Microphotograph of the nucleus caudalis The cells of the nucleus caudalis closely resemble those of the dorsal horn of the spinal cord Figs 2 to 4 Different cell types from the subnucleus magnocellularis Mag 1 000 × Figs 5 to 8 Cells from the subnucleus gelatinous Mag 1 000 × Figs 9 to 12 Different cell types from the subnucleus zonalis Mag 1 000 × Figures and legend from Olszewski and Baxter *Cytoarchitecture of the Human Brain Stem* 1954 Courtesy S Karger Basel and J B Lippincott Philadelphia

cranial pressure and drag upon the dural veins can be a problem of some moment On the other hand in the prone position respiration may be impaired and thus complicate the procedure With the patient horizontal on his side and with the table tilted upward at the head, 35 to 45 degrees bleeding is more easily controlled and the position may be readily altered if need be

Incision A midline incision is made as for a high cervical laminectomy extending from the occipital protuberance to about the third cervical The arch of one half of the atlas and one half of the foramen magnum are then removed and the dura is opened lateral to the midline

Fig 82 Microphotograph of nucleus tractus spinalis trigemini interpolaris The nucleus tractus spinalis trigemini interpolaris lies in the lateral part of the medullary tegmentum It extends from the junction of the caudal and middle thirds to the junction of the middle and oral thirds of the inferior olivary complex — a distance of [illegible] mm Orally the nucleus is directly continuous with the nucleus tractus spinalis trigemini oralis and *caudally with the nucleus tractus spinalis trigemini caudalis* 1 Nucleus tractus spinalis trigemini interpolaris Mag 150 × 2 Medium sized cells with eccentric nuclei and peripherally arranged Nissl granules from the nucleus tractus spinalis trigemini interpolaris Mag 1 000 × 3 Small cells from the nucleus tractus spinalis trigemini interpolaris Mag 1 000 × Figure and legend from Olszewski and Baxter *Cytoarchitecture of the Human Brain Stem* 1954 Courtesy S Karger Basel and J B Lippincott Philadelphia

Unfortunately on the brain stem there are no definite dorsal surface landmarks since there is no dorsal root here and the motor root lies ventral to the uppermost dentate ligament It is generally accepted that the superior limit of the spinal cord corresponds to the uppermost rootlet of the first cervical segment

Fig 83 Microphotograph of nucleus oralis Fig 1 Nucleus tractus spinalis trigemini oralis Nucleus oralis extends 8 mm (Personal communication from Dr Olszewski) Mag 150 × Figs 2 to 4 Cells from the nucleus tractus spinalis trigemini oralis Mag 1 000 × Figure and legend from Olszewski and Baxter *Cytoarchitecture of the Human Brain Stem* 1954 S Karger Basel and J B Lippincott Philadelphia

which marks the most caudal fibers of the pyramidal decussation This is at a level slightly above the upper border of the arch of the atlas Considerable variation exists in the overall length of the cord the medulla in the female extends somewhat more caudad than in the male Consequently the precise level at which the

incision is made is likely to be inconstant and variable Attention has been called to the difference in position of the tuber cinereum from individual to individual, and even on the two sides in the same person

McKenzie (1955) reporting his experience with tractotomy used the line of the second cervical dorsal root fibers as a guide to the medial point at which the incision is begun moderately undermining the cuneate funiculus in order to be sure to sever the mandibular fibers which lie most dorsal in the trigeminal tract He then carried the incision to a depth of 4 to 5 mm to emerge in line with the rootlets of the spinal accessory Since there is considerable variation in the position of the caudal extension of the medulla a less variable landmark is desirable The first cervical ventral root though slightly more difficult to visualize might be a more fixed point from which to determine the level of the incision since it bears a more constant relation to the pyramidal decussation and hence to the internal structure of this part of the junction of medulla and spinal cord

A point which has not been stressed is that the incision into the tract not only severs trigeminal fibers but also enters the nucleus and the soft gray matter of which the nucleus is composed and may entail a more extensive longitudinal lesion than is realized This may explain some variations encountered in the procedure

Falconer followed the technique of Olivecrona—a straight incision to the level of the third cervical After a sufficient area of occipital bone and the arch of the atlas are brought into view two burr holes are made and the bone is removed over a sufficient area of exposed dura including the posterior margin of the occipital bone

The dura is then opened in a V shape the basal cisterns are emptied and the tonsil on the side of the operation is elevated The obex is identified and the point of incision selected The emerging rootlets of the spinal accessory nerve are seen on the lateral aspect of the medulla which outlines the ventrolateral border of the trigeminal tract Rarely can the tuberculum cinereum be identified Falconer sought the midline of the medulla and its posterior surface was then divided into equal parts,

lateral and medial The lateral portion thus located corresponds with the course of the descending tract

While Olivecrona located the trigeminal tract by searching the area with gentle pressure until the patient complained of pain Falconer used a straight needle to prick the medulla to a depth of 3 mm Slight momentary pain is experienced when the tract is reached After it was identified the knife was inserted to a depth of 3 mm to emerge on the lateral surface of the medulla in line with the accessory rootlets The incision is extremely painful Falconer forewarned his patients however and says that though the pain is intense they did not shift their position The face was then tested for pain If satisfactory analgesia had not been obtained sections were made until the desired divisions were found to be analgesic

Falconer found it easier to section the ophthalmic and maxillary than the mandibular If the ophthalmic were not cut he carried the incision further in a ventrolateral direction and if the mandibular were spared and analgesia was desired in that division then he continued with great caution to the midpoint between the dorsolateral border of the medulla and the midline Generally however it was felt preferable to make a fresh incision higher up Under no circumstance was it considered permissible to exceed a depth of 3 mm Falconer found that a new level at 2 or 3 mm distance often sufficed to obtain the analgesia desired In this connection it is interesting to note that in spite of the use of local anaesthesia and the induction of pain by pricking the area seven of eleven unilateral trigeminal neuralgia patients had three separate incisions in two cases two separate cuts were required and in only one was the tract adequately identified and cut at the first attempt

The incision in the medulla and cervical cord is usually bloodless If a twig was found to cross the point selected Falconer used the cautery to coagulate the vessel and was apparently not disturbed if two or even three separate incisions were required

After the unfavorable results with his original procedure Sjoqvist (1948) modified his technique making an incision at the level of the obex from 2 to 2 5 mm deep Though he adopted the tuberculum cinereum as a landmark he quotes

Jiminez Gonzales to the effect that this prominence is variable in its position differing even on the two sides in the same individual Actually he was able to identify it in but fifteen of the twenty three cases which he reported Others have likewise found difficulty with this landmark Its use implies variation in the site of the incision and consequently inconstant results

Areas of Induced Analgesia Compared with Trigeminal Divisions Primarily Involved, Associated Neural Deficits We are indebted to Grant and Weinberger for a series of careful studies of tractotomy both at the higher level advocated by Sjoqvist and also at the lower levels which they proposed Their study of the immediate and late complications is detailed and permits of critical evaluation as do also the reports of Guidetti (1950) Hamby *et al* (1948) Grant (1948) Falconer and McKenzie Weinberger and Grant (1943) reported on eighteen patients in ten of whom the operation was performed at the level of the obex and in eight at a somewhat lower level namely 6 to 8 mm below the obex—thus in the first cervical segment Of these eight patients six were operated upon for trigeminal neuralgia and two for malignant tumors The divisions involved in those with trigeminal pain and the divisions rendered analgesic were as follows (the divisions in which analgesia was produced and in which pain had not existed are indicated in italics)

	Divisions Involved	*Divisions Rendered Analgesic*
Case 12	I and II	I and II and in addition *III*
13	II and III	II and III and in addition *I*
14	III	III and in addition *I and II*
16	Root section on right II on left	II and in addition *I and III*
17	I II and III	I II and III
18	II and III	II and III and in addition *I*

Case 18 In spite of analgesia of the maxillary division paroxysms of trigeminal pain with a trigger point in the upper lip still remained In reporting on these patients Grant (1948) stated that five of the six subsequently required dorsal root section

In addition to the induction of analgesia in divisions free of pain a number of unfavorable neural deficits were brought on by the operation which Grant felt might have been overlooked had not the patients been made to get out of bed for tests of

equilibrium ataxia and dysmetria Some of the neural defects noted were numbness and tingling of the ipsilateral hand and fingers with loss of muscle joint and tendon sense in wrist and fingers incoordination of the ipsilateral arm and leg disturbances of equilibrium walking with a wide base and staggering on sudden turning While most of these sequelae were maximum during the immediate postoperative period some persisted for weeks and months One patient still complained of mild tingling

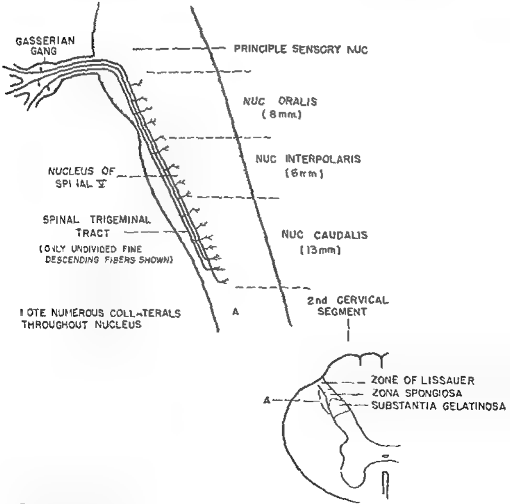

Fig 81 *Schematic drawing of spinal trigeminal tract and nucleus* The cells of the nucleus caudalis represent the cephalic *continuation* of the cells forming the cervical dorsal horn The larger trigeminal fibers are not *shown* Numerous collaterals from all fibers are given off throughout the trigeminal nucleus

in the fingers after three months he experienced awkwardness in the use of the hand in complicated movements and his gait became unsteady with fatigue In addition to such unfavorable effects hospitalization was prolonged and resumption of former activities delayed compared to patients on whom subtemporal dorsal root section was done

Guidetti (1950) reported on 124 trigeminal tractotomies from Olivecrona s clinic On forty patients the operation was done at the level first suggested by Sjoqvist the junction of the middle and lower thirds of the olive On eighty four it was performed at or a few millimeters caudal to the obex The overall operative mortality for the complete series was 1 6 per cent a tribute to the care and skill of the surgeon It was found that pain in the mandibular area cannot always be abolished that analgesia is greatest and more constantly obtained in the ophthalmic division that while some patients experienced considerable diminution of pain perception in others there was thermaesthesia in the face either complete or predominantly for heat or cold Similar findings were recorded by Spiller in syringomyelia and by Stookey (1929) in sectioning the spinothalamic tract in the thoracic cord which suggests that there may be separate fibers for these two modalities

Dysaesthesia nystagmus incoordination of the ipsilateral arm and sometimes of the leg weakness of the body on the affected side and a tendency to fall on the side of the operation were among the neurologic sequelae observed These neural deficits lasted in some instances for several weeks while in others difficulty in riding a bicycle or walking in the dark persisted for a matter of years Of the forty patients operated on 2 to 6 mm rostrad to the obex twenty seven showed some of these disturbances In fourteen these symptoms disappeared in a few weeks in twelve they lasted for several months and in one for several years The spinothalamic tract was injured in ten patients producing more or less extensive areas of analgesia and thermaesthesia on the contralateral side of the body in some instances involving only the foot and leg in others extending onto the trunk Corneal reflex was lost in the majority of the patients Recurrences developed in forty six patients or 37 per cent of these fourteen had an additional dorsal root section and in three tractotomy was repeated immediately

Brodal (1947) studied the sensory changes in four patients on whom tractotomy was done at the junction of the lower and middle thirds of the olive He found analgesia about the concha of the auricle part of the antihelix the posterior third of the tongue the tonsils and the pharynx on the side of the operation Apparently prior to Brodal s study these areas had not been investigated following tractotomy though from a comparative anatomical standpoint it had long been known that the somatic fibers of the facial glossopharyngeal and vagus on entering the brain stem joined the descending trigeminal tract

Hamby Shinners and Marsh (1948) reporting on thirty five trigeminal tractotomies for trigeminal neuralgia enumerated some of the neural defects encountered in twenty eight patients who could be followed Unfortunately the division primarily affected and the subsequent area of analgesia in this series are not stated The first five patients were operated upon at the lowest vagal level and only one of these was examined for and found to have ataxia in four the operation was at the level of the obex and of this group three showed ataxia of the arm —two to a severe degree five were operated upon 4 mm below the apex with slight ataxia resulting in one In twenty one the site of incision was 10 mm below the obex fifteen of this group were examined and four showed minimal ataxia of the ipsilateral arm Summing up Hamby stated that ataxia of the arm was present in eight of twenty four patients or 33 per cent

Dysaesthesia in the face occurred in twelve of the twenty eight cases reported by Hamby and his associates or 43 per cent Five patients were recalled for examination of the glossopharyngeal and vagal areas Of these three had complete analgesia of the face and in addition of the ipsilateral half of the tongue palate uvula tonsil and pillars and the accessible part of the pharynx

In this series also analgesia was obtained most uniformly in the ophthalmic division and least often in the mandibular The depth of the incision rather than its level was believed by Hamby to be the controlling factor Residual areas of sensation were found in 54 per cent of the cases chiefly in the second and third divisions Ten of the twenty eight patients followed were completely free of pain six had typical but bearable trigeminal

pain and seven or 25 per cent had recurrence Six of the last group accepted dorsal root section Thus only about one third of the patients were completly relieved of their pain by tractotomy

The distribution of the pain in Falconer s trigeminal series and the analgesia induced after tractotomy are shown in the following tabulation

Trigeminal Division Affected	*Divisions Rendered Analgesic*
I Alone	I and in addition *II III IV and V*
I Alone	I and in addition (II III previously done) *IV and V*
I Alone	I and in addition *II and III IV and V*
I Alone	I and in addition *II and III IV and V*
II Alone	II and in addition *I and III IV and V*
II Alone	II and in addition *I and III IV and V*
II Alone	II and in addition *I and III IV and V*
II Alone	II and in addition *I and III IV and V*
III Alone	III and in addition *I and II IV and V*
I and II	I and II and in addition *III IV and V*
I and II	I and II and in addition *III IV and V*
I and II	I and II and in addition *III IV and V*
II and III	II and III and in addition *I IV and V*
I II *and* III	I *II and III and in addition IV and V*

As in other series analgesia was induced in areas originally free of pain not only in the trigeminal distribution but also in regions in which pain was unlikely ever to appear The surgical axiom calling for conservation of as much and destruction of as little as possible thus seems to have been disregarded in tractotomy In six of Falconer s patients slight but persistent ataxia remained but according to him this is the only undesirable complication noted in the series and is in no instance disturbing Some patients showed dysaesthesia in the face described as pins and needles or itching

Sjoqvist (1948) reported on twenty three personal cases not previously published Eleven of the patients were operated on for trigeminal neuralgia but the divisions affected are not given In these eleven patients complete analgesia in all three divisions was obtained in 36 4 per cent in none of the remaining cases

was analgesia effected in both the second and third divisions which are most commonly involved in trigeminal neuralgia In only one instance was analgesia induced in the third division Unfortunately Sjoqvist made no statement as to the number who originally had pain in the ophthalmic though analgesia in this division resulted whether or not pain was present

McKenzie has given an excellent analysis of the postoperative sensory findings and other neurological deficits in forty one patients In two of these the incision in the trigeminal tract was bilateral so that actually forty three incisions were made The level and depth of the incisions in these cases are given thus permitting a thorough evaluation of the results in each instance In most of the patients the incision was carried to a depth of 4 to 5 mm The degree of analgesia obtained at different levels was attributed to the level of the incision in relation to the obex and not to the depth Some of McKenzie s statistics are shown in Table 3

TABLE 3
AN ANALYSIS OF TRIGEMINAL TRACTOTOMIES

Complete analgesia of the skin of the face and inside the mouth (25 incisions)	Incomplete analgesia of the skin of the face and inside the mouth (18 incisions)†
7 incisions 1 2 mm below the obex	2 incisions 1 [illegible] mm below the obex
15 incisions 3 5 mm below the obex	7 incisions 3 5 mm below the obex
3 incisions 6 7 mm below the obex	9 incisions 6 7 mm below the obex

* [illegible] patients with complete analgesia had spinothalamic tract injuries involving leg buttock and in a few the mid thoracic

† Of 17 patients with incomplete analgesia the tract was partially severed in 7 with involvement of the leg buttock and in 1 case up to the chin

‡ In the total group 15 patients had in addition analgesia of the nasopharynx ear canal and drum Two had analgesia of the ear canal and drum with preservation in the nasopharynx One patient had no alteration

McKenzie found as had Grant and Weinberger that ataxia and dysmetria were marked during the first few days following operation but were usually transient lasting a few days or weeks In ten cases however the signs persisted months after the operation and the disability was considered permanent One patient had to be careful in handling dishes since the whole arm showed

slight incoordination in another both the arm and leg were involved Four patients were unable to discriminate textures and had difficulty in handling small objects

With a single exception corneal analgesia was found to be complete

It was McKenzie s impression that paraesthesias are just as frequent if not more so than after section of the sensory root but so far none have reached the same severity as occasionally seen after section of the sensory root

Evaluation of Trigeminal Tractotomy Nucleo Tractotomy In view of the results of tractotomy reviewed above it may now be asked whether the ends attained justify this procedure

The aim of treatment in trigeminal neuralgia is minimum loss of sensation—whether analgesia or anaesthesia—compatible with *destruction of the fibers from the division or divisions involved* Deliberately to produce areas of analgesia beyond the territory involved particularly in the ophthalmic division cannot be accepted as in accord with the soundest principles of trigeminal surgery The production of analgesia in the distribution of neighboring nerves about the face and mouth which are never involved in trigeminal neuralgia namely the glossopharyngeal vagus and second cervical segment is a further contraindication to the procedure On the basis of these considerations alone the operation is of doubtful value in the treatment of trigeminal neuralgia

It has been shown further that even in the most skilled hands neural deficits frequently lasting are incurred in areas remote from the trigeminal distribution and that in about a third of the cases injury to the spinothalamic tract results in loss of pain and temperature sense on the opposite side of the body The disagreeable dysaesthesias incident to dorsal root section also appear in a relatively high percentage of cases though they appear to be less annoying than in some instances after dorsal root section

Nor can total analgesia in the division primarily involved especially the mandibular which is the most commonly affected be fully assured In the distributions of the second and third divisions there may remain islands not rendered analgesic which are potential sources of recurrent pain Indeed recurrences have been common Five of Grant s six patients subsequently had to have

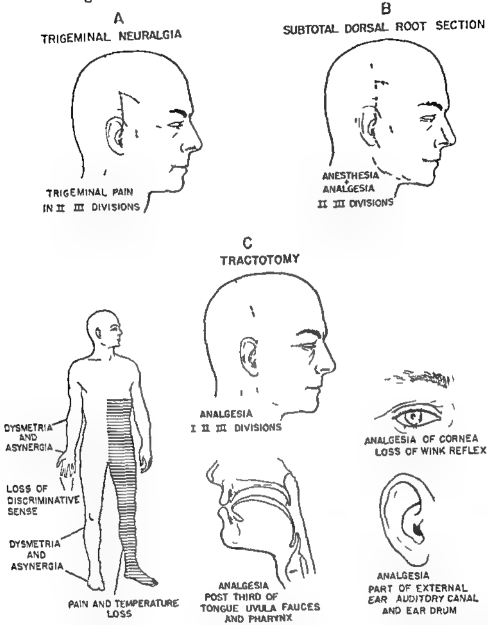

Fig 85 Trigeminal tractotomy for the relief of trigeminal neuralgia A Trigeminal pain in II and III divisions B Area of analgesia and anaesthesia following subtotal dorsal root section C Pain in II and III divisions as shown in A Note neural defects commonly associated with trigeminal tractotomy for the relief of trigeminal neuralgia In spite of no pain in I division this area is more certainly rendered analgesic than the II or III divisions Analgesia is also produced in the posterior part of the tongue uvula fauces and pharynx as well as in part of the external ear auditory canal and ear drum In addition remote and unrelated neural defects shown on figure at left may occur Trigeminal tractotomy for the relief of trigeminal neuralgia is in the authors opinion not a justifiable procedure

dorsal root section while in Hamby's series of twenty eight only ten were permanently and completely relieved by the original operation Practically all of McKenzie's series of seventeen patients who had residual pain spots in varying areas though they remained well for six months or longer eventually complained of recurring pain Five had submitted to partial section of the sensory root at the time of McKenzie's report and he believed that further operations would be necessary on most of them Thus even in hands as skilled as McKenzies permanent relief cannot be assured

Since these associated disturbances occur in the experience of the most skilled and cautious surgeons it is apparent that in spite of the greatest care injuries to adjacent neural structures are almost inevitable A survey of the anatomical relations suffices to explain this Especially to be taken into consideration in operations at the proposed lower level is the position of the obex taken as a landmark which contributes to the uncertain and capricious results The obex does not maintain a constant level in relation to the tracts and nuclei of the region the length of the medulla and upper cervical segments is variable, and the region is in itself one of changing structural neural patterns The pyramidal decussation for example which cuts off the posterior horn causing it to become a part of the trigeminal nucleus does not always occur at the same level The nuclei of the funiculus gracilis and cuneatus are here in the process of forming pushing into the tract itself with some displacement of the more lateral fibers reaching the cuneate funiculus from the neck and upper extremity These fundamental changes do not take place at a fixed and precise level which can be determined on the surface of the brain stem and the first cervical segment Yet these relationships are determining factors in the neural structures implicated in the incision

Ferraro and Barrera (1935) have shown that the nucleus cuneatus is divided into a medial and a lateral portion The lateral portion receives a large number of fibers from the neck and upper extremity which pass to the cerebellum whereas those to the medial portion pass *via* the arcuate to the thalamus It is the lateral fibers and the lateral nucleus which are more likely

to be injured in tractotomy in the region of the obex since they lie in immediate juxtaposition to the dorsal portion of the trigeminal tract and the mandibular fibers To attempt a section in this region which requires precision not only in respect to the level selected but to the depth of the incision is to attempt to visualize with accuracy a changing structural pattern which cannot be foreseen

Actually the operation which we have been discussing is not a tractotomy alone since it combines section of the descending trigeminal tract with *section into the trigeminal nucleus* It should be called therefore as we have designated it descending trigeminal nucleo tractotomy This is of importance since we are more familiar with the sequence of events after the destruction of nerve fibers distal to their ganglion than with the detailed changes which take place when one or more sections are made in the soft gray matter of the nucleus To what extent rostrad and caudal alterations occur in the gray after section has not been completely studied One cannot but speculate as to the fate of sections when they are made in sequence 2 to 3 mm apart as was done in Falconer s series This must entail separation of a relatively large area from its blood supply

Falconer concluded that there are three main indications for tractotomy in trigeminal neuralgia (1) first and *possibly* second division trigeminal neuralgia (the italics are the author s) (2) bilateral trigeminal neuralgia (3) persistent pain following complete sensory root section

Sjoqvist at the end of ten years believed that tractotomy was inadvisable in patients over sixty or in trigeminal neuralgia involving the mandibular division Unfortunately the majority of patients *are* over sixty and the *mandibular division is* the one most commonly involved Even were these the only restrictions this operation would be extremely limited in value

After viewing the evidence gained it would appear that the question suggested above must have a negative answer *In our opinion, the ends attained by trigeminal tractotomy do not justify the procedure in the surgical treatment of unilateral or bilateral trigeminal neuralgia*

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would not lose the normal fifth nerve sensations Lee was prompted to this concept by assuming that the mechanisms causing trigeminal neuralgia and meralgia paraesthetica were comparable

No one has *demonstrated* that the dorsal root is compressed at this point, nor that the petrous ridge with its dural covering presents a sharp margin causing pathological changes within the root Taarnhøj himself in his first report on ten patients, made no mention of having found the dorsal root compressed or abnormally angulated nor did he present any evidence in his 1954 report on seventy six patients that any compression of the root was found

Love and Svein (1954) reporting on one hundred operations of this same type, did not refer to any abnormalities of the root as it made its entrance into the posterior fossa through its dural sheath though the root was exposed and brought into view Woolsey (1955) operated on forty five patients without presenting any evidence that the dorsal root was abnormal We are thus forced to content ourselves with conceiving of a site where "it is possible to imagine" the trigeminal root to be compressed

Gardner and Pinto (1953) found in the Taarnhøj operation fascinating grounds for speculation, and predicated that with advancing years the tentorium sags, that the oval dural opening is transformed into a slit, and that this may be accompanied by a mild platybasia due to osteoporosis which frequently accompanies old age Gardner, Todd and Pinto (1956) elaborated this concept further after comparing the radiographic findings in 130 persons with trigeminal neuralgia and those in a control series of 200 persons in whom no intracranial lesion was suspected but who did not have trigeminal neuralgia In both groups there was a relatively high incidence of platybasia which they realized required further investigation In the control series the number of patients in the later decades was too few for comparison as to this point At all events the authors believed that their studies indicated a correlation between platybasia age sex and trigeminal neuralgia Actually however the low incidence of trigeminal neuralgia in the older population as a whole makes its relationship to the aging processes described a matter of rather

CHAPTER XVII

TRIGEMINAL DORSAL ROOT DECOMPRESSION—COMPRESSION BLOCK OF THE GREAT AURICULAR AND THE GREAT OCCIPITAL NERVES

The test of time and further experiences can alone decide what value will be finally attached to this measure but at any rate the outlook is hopeful and let us hope the future will not belie our present expectations

— William Rose

New procedures have been advanced within the last five years designed to abolish trigeminal pain without anatomical or physiological interruption of the trigeminal nerve fibers Taarnhøj's (1952) decompression of the dorsal root Pudenz and Shelden's (1952) decompression of the second and third divisions of the trigeminal nerve at the foramen rotundum and ovale and compression rather than decompression of the trigeminal dorsal root as suggested by Shelden Pudenz Freshwater and Crue (1955) Entirely different concepts are involved in the proposal of Wyburn Mason (1953) to abolish the pain of trigeminal neuralgia by section or block of the great auricular nerve and that of Skillern (1954) to accomplish the same end by injecting the great occipital nerve

In Taarnhøj's original article he refers to one site where it is *possible to imagine* that quite small changes in the tissues could give rise to compression that site being the dural canal over the *sharp margin* of the petrous ridge (authors italics) It is on this assumption that he suggested dorsal root decompression

Lee (1937) anticipated Taarnhøj's suggestion but accompanied his remarks with the practical comment that the idea could be put to the test by removal of the bone underneath the sensory root The patient would then not only be freed of his pain but

would not lose the normal fifth nerve sensations Lee was prompted to this concept by assuming that the mechanisms causing trigeminal neuralgia and meralgia paraesthetica were comparable

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fanciful speculation Gardner suggested still another factor namely demyelination with the nerve fibers no longer loosely arranged but held together permitting a short circuiting of the action current accompanying the passage of the nerve impulse and formation of an artificial synapse Unfortunately for the validity of this theory no pathological evidence of demyelination in the dorsal root has ever been demonstrated

Were one to accept the assumption of increased angulation and sagging with tension on the nerve root the logical course would be to cut off the apex of the protruding petrous ridge so as to lower the ridge over which the nerve must pass and by which the nerve root is compressed This is not accomplished by dorsal root decompression as described nor has any neuro surgeon proposed that such a procedure be done

Furthermore if the root fibers were compressed by the dural canal and petrous ridge then objective sensory findings and pain more or less constant and not paroxysmal should be present since the pressure upon the nerve root would be continuous Again if increased angulation is assumed the motor root being under the sensory should bear the brunt of this change and motor signs should be among the earliest manifestations Nerve compression existing for any length of time at the elbow or wherever else it is found is invariably accompanied by gross pathological changes in the nerve at the point of pressure No such pathological lesion has ever been found in trigeminal neuralgia

Shelden addressing the American Academy of Neurological Surgery in 1952 described a somewhat different type of decom pression procedure He had treated ten patients by decompression of the divisions of the trigeminal nerve at the foramen ovale and foramen rotundum While he refrained at that time from publishing this series because of the short interval that had elapsed since treatment he was able three years later writing with Pudenz Freshwater and Crue to report excellent long term results He and his associates were impressed by the fact that both *decompression of the maxillary and mandibular divisions at the* foramina of exit and decompression of the dorsal root were effective in the relief of trigeminal pain though one operative

attack was distal and the other central to the ganglion The two procedures they reasoned must have a common denominator, and this they thought to be operative trauma to the nerve fibers It would appear they conclude that compression of the trigeminal fibers during operation is the factor that has afforded relief of pain with the so-called decompression procedures With this in mind they substituted posterior root compression which at the time of their report they had performed in twenty nine cases with good immediate results While neither operation rests upon proved anatomical or pathological grounds yet with each procedure apparent cures have been obtained without significant objective loss of sensation It has been concluded that the improvement obtained is due to diminishing the total number of impulses which could be conveyed by the trigeminal nerve Though admittedly the time is still too short to permit of full evaluation of either the compression or decompression operations yet the results have been sufficiently encouraging to warrant their continuation on an *experimental basis,* since only time will allow a full determination of their relative merits We are extremely skeptical and doubt the ultimate value of the procedure

Inasmuch as the two procedures appear to be based on a common premise and compression as advocated by Shelden and his co-workers is a simpler method with fewer complications this appears to us to be preferable The decompression operation entails possible damage to the third fourth and sixth nerves as pointed out originally by Taarnhøj and is also likely to produce considerable bleeding from the superior petrosal sinus and the cavernous sinus though this can generally be readily controlled by application of Gelfoam

Taarnhøj reverts to the intradural approach first used by Horsley in 1891 to reach the dorsal root His technic is as follows

> *The temporal intradural approach* has been the standard method Local anesthesia is used usually with some Pentothal The patients are placed on the back in a horizontal position with the head turned to the side No hypotensive drugs are used and no lumbar puncture is performed
>
> The operation is performed through a vertical incision in the temporal region reaching the zygomatic arch and a small

triangular craniectomy about 1½ x 1½ just above the base of the skull the temporal vessels being ligated and the soft tissues drawn apart with a self retaining retractor For a time the foramen spinosum was plugged extradurally but now the author feels that the bleeding is about the same during the opening of the cavum Meckli without this procedure and in the last some 10 cases the foramen has not been plugged

The dura mater is opened by a T shaped incision and the wings of the cut dura mater are fixed to the muscle with a couple of stay sutures The surface of the brain is covered by pieces of cotton and the temporal lobe is elevated from the base of the skull with a ribbon retractor At the same time the head is lowered Generally the veins running from the temporal lobe to the dura mater can be avoided but in 20 cases in this series it has been necessary to cut one or more of the veins which in no instance caused any postoperative complications

The dura mater in the middle fossa is palpated with a forceps Posteriorly the tentorium feels soft and just in front of this the superior petrosal sinus is seen at the edge of the petrous part of the temporal bone In some cases the superior petrosal sinus is very small and difficult to observe The cavum Meckli usually can be very easily located as the most lateral part of the middle fossa where the dura mater is not tightly bound to the base of the skull but soft and yielding to the palpating instrument—just in front of the superior petrosal sinus

With a sharp knife and scissors the dural roof of the cavum is opened widely Care must be taken not to injure the root fibres and not to incise the cavernous sinus which is directly medial to the cavum If this happens the lesion of the sinus may be plugged with gelfoam The incision over the cavum is continued posteriorly above the trigeminal root through the superior petrosal sinus which is divided between clips For this purpose special scissors and clips forceps are used called Olivecrona's tentorium scissors and clips forceps The bleeding from the sinus in some cases may be difficult to control but diathermy should not be used The diatherm is practically never used by the author at the base of the skull during this operation as he feels it is important not to do so

There have been two cases of facial palsy following the use of diathermy in this region

In most cases the tentorium has been divided to its free edge but attention must here be drawn to the trochlear nerve which lies close upon the free edge of the tentorium and disappears into it just behind the superior petrosal sinus Therefore the incision through the tentorium just behind the sinus should be made in a direction that is posterior and a little lateral for some centimetres and then turned medially to the edge Even a very slight pull upon the nerve may cause a trochlear palsy

At a re-operation upon one of the patients who had recurrence after a decompression of the trigeminal root it was found that the posterior angle of the tentorial incision which in this case had not been continued to the free edge of the tentorium had retracted in a forward direction since the first operation and now was pressing upon the trigeminal root The incision then was enlarged to the free edge and the patient was free from pain Therefore as far as the author can see an important advantage of the intradural approach is that one can cut the tentorium and in this way perhaps diminish the risk of recurrence

By the extradural approach it is difficult to cut back farther than the sinus The author also felt that visualization is better by the intradural method and that bleeding is less and more easily controlled However he had only seen the extradural approach used by others but had never tried it himself

Most surgeons prefer to use the extradural procedure as suggested by Love (1954)

> Through a small subtemporal craniectomy opening the middle meningeal artery is ligated and divided The dura mater is stripped from the foramen ovale upward and backward to expose the intracranial portion of the third branch of the trigeminal nerve the gasserian ganglion and the dura propria over the adjacent portion of the posterior root of this ganglion The dura mater underneath the temporal lobe is then incised *posteriorly parallel to the* posterior root of the ganglion and the tentorium overlying the posterior root in the posterior fossa is also incised By this technic the posterior root of the gasserian ganglion is thoroughly decompressed

Shelden Pudenz Freshwater and Crue also recommend an extradural approach for compression of the posterior root They describe their technic as follows

> The dura mater was reflected from the dura propria in the usual manner using a small dental roll The posterior portion of the ganglion and adjacent part of the posterior root were exposed A small vertical opening was made in the dura propria near the ganglion thus exposing the posterior root fibers Care was taken not to expose more than a minimal portion of the posterior root so that the procedure would in no way be considered as the usual decompressive technic
>
> After the fibers were exposed they were gently compressed with a small portion of a dental roll if the patient s pain involved the second and third divisions If the patient s pain was limited to either division alone a small blunt instrument was used to compress selectively the appropriate fibers of the root More recently the back of a blunt dissector has been used as the instrument of compression

Wyburn Mason suggested that the great auricular nerve derived from the ventral primary divisions of the second cervical segment was responsible for trigeminal neuralgia and recommended section or alcohol block of that nerve in the neck to abolish trigeminal pain providing pain did not occur in the tongue He cited fifty six cases of trigeminal neuralgia in all of which relief was obtained either by alcohol injection or section of the great auricular nerve Only two patients had a return of pain—one two and a half and the other three and a half years later Unfortunately the criteria used in making the diagnosis of trigeminal neuralgia were not defined One patient who had had carcinoma of the tongue a second who had herpes zoster of the second and third cervical segments and a third who had received x ray therapy for Hodgkin s disease were included in the series In such cases the diagnosis of trigeminal neuralgia is not warranted

Crue Shelden Pudenz and Freshwater (1956) reported several cases with third division pain without involvement of the tongue in which block of the great auricular nerve had not helped significantly

An admirable critical study of Wyburn Mason's concept was made by Penman and Walsh (1957) Fifty nine patients with trigeminal neuralgia were told of two possible measures to obtain relief either section of a nerve in the neck or alcohol injection of a branch of the trigeminal and were permitted to select the procedure of their choice with the understanding that their names would be placed on a waiting list for treatment Twenty three chose section of the great auricular nerve The

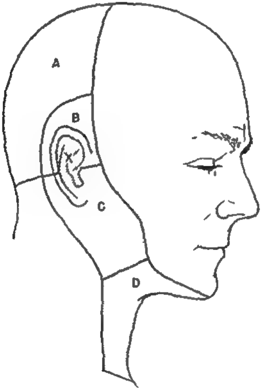

Fig 86 Cutaneous areas supplied by peripheral nerves immediately adjacent to the trigeminal innervation

nerve was exposed as far central as possible Squeezing and pulling upon it caused the majority to feel pain in the ear, two had pain in the neck and none had any sensation within the trigeminal area After the nerve was identified and tested 1 cm was excised

Within a period of eighty five days twenty two of the twenty three patients who had had great auricular sections required alcohol injection into the trigeminal nerve for the relief of pain whereas in sixteen untreated patients comparable in every way injections became necessary within 118 days It was thus concluded that great auricular neurectomy had no effect on trigeminal neuralgia

This was a carefully controlled clinical experiment of great value Unfortunately the authors did not designate the trigeminal divisions involved nor did they give figures as to the sensory loss which followed section of the great auricular nerve

Skillern (1954) treated one hundred patients having trigeminal neuralgia by block of the great occipital nerve with one hundred per cent success the patients remaining free of pain from six to twelve months He expressed the opinion that the syndrome of trigeminal neuralgia presented symptoms confined to the distribution of the great occipital nerve and that these symptoms were shared by the trigeminal nerve or shown by this latter nerve as a nocireceptor to passive stimuli of the vulnerable great occipital nerve Thus he held the great occipital nerve primarily to be responsible for trigeminal neuralgia

Crue and co workers found that block of the great auricular nerve gave complete and immediate relief in one patient having severe pain in both the second and third trigeminal divisions including the tongue with trigger points in all three divisions These findings and Skillern s successes with block of the great occipital nerve may be of considerable significance since it is well known that the second cervical segment overlaps to a variable degree the trigeminal area in both the primary dorsal and primary ventral division from which are derived the great occipital and the great auricular nerves respectively It is possible as Crue and his associates suggest that the second cervical segment may have a reinforcement or summation value and that if

blocking one nerve does not give complete relief, the additional block of another will add to the effect It has never been suggested however that the overlap of the second cervical reaches into the primary trigeminal area *i e*, the central facial region lips nose eyebrow and forehead where most of the trigger points in trigeminal neuralgia are found and where trigeminal pain is most intense

As has been pointed out elsewhere (see Anatomy) the trigeminal and the second cervical nerves are in juxtaposition peripherally in their cutaneous innervation and also centrally at the junction of the descending trigeminal tract and the second cervical segment The more caudal part of the descending trigeminal nucleus is but the cephalic continuation of the substantia gelatinosa of Rolando of the first and second cervical segments Thus it may well be that the central focus of pain in trigeminal neuralgia is in the caudal trigeminal nucleus and that the sudden discharge of pain impulses in this region may be lessened by blocking incoming stimuli from adjacent and interlocking areas In a few cases blocking of the great occipital, lesser occipital and great auricular nerve has afforded temporary relief The fact that such a response may be obtained even in a few instances is of significance and warrants further investigation If this theoretical concept were tentatively accepted its value could readily be established or disproved by selecting those patients in whom block of the second cervical nerve at its exit afforded relief of pain and trigger discharge, and following this by section of the second cervical dorsal root Should relief thus obtained prove of lasting value numbness in the second cervical region would surely be preferable to numbness in the face such as occurs after trigeminal dorsal root section It is in this field that further investigation is needed and may prove of value in selected cases

On the basis of our operative experience with recurrent pain it is doubtful if any of these newer procedures will prove of lasting benefit Abbott (1957) in a personal communication stated he soon became convinced that it was traumatization of the dorsal root rather than decompression which gave relief and Cleveland (1957) in a personal communication said he had operated on forty seven patients within two years but had re

operated on twenty of these to sever the dorsal root and that the majority of the remaining twenty seven have had some twinges of pain He added that he doubted whether any operation other than dorsal root section is going to hold up With this conclusion we heartily concur

CHAPTER XVIII

STATISTICS OF SUBTEMPORAL DORSAL ROOT SECTION—AN ANALYSIS OF CASE MATERIAL AND OPERATIVE RESULTS

The records operative findings and follow up studies on 674 patients who had a total of 728 posterior root sections done by the senior author between the years 1925 and 1955 inclusive served as the source material for this chapter Six hundred and fifty six patients with true trigeminal neuralgia had a total of 710 posterior root sections *via* the subtemporal approach In addition there were five patients with multiple sclerosis and pain in the trigeminal distribution and four with tumors three of which produced the symptoms of trigeminal neuralgia and were operated upon There were nine patients with atypical trigeminal neuralgia whose pain was sufficiently characteristic and severe to warrant posterior root section. Since operation was done in all eighteen cases they are included in the mortality statistics but not in the sections pertaining to an analysis of orthodox trigeminal neuralgia *

Hospital records were reviewed and patients followed by letter and questionnaire More than one hundred of the more recent patients were seen in follow up visits during the first six months of 1957 Every effort was made to obtain reliable long term information from patients and from the families of patients who had died

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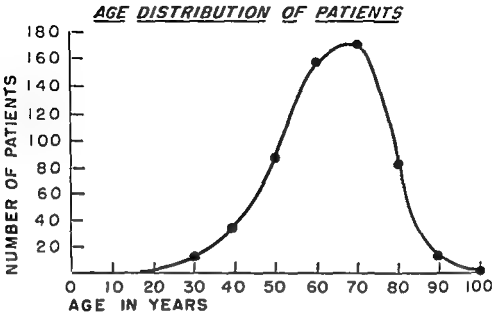
During the thirty years covered in this study the records of fourteen patients operated upon could not be located and therefore were not included in the statistical study The discharge diagnoses mortality records and Department of Pathology records of the Neurological Institute of New York and of Columbia Presbyterian Medical Center were doubly checked to determine if any deaths occurred among these fourteen no deaths were recorded under their name



GRAPH I Age distribution of patients operated upon for trigeminal neuralgia

Age As can be seen from the accompanying graph the incidence of operation for trigeminal neuralgia was highest in the decade between sixty and seventy years 77 per cent of the patients were over fifty years of age The youngest patient to undergo operation was twenty four having had trigeminal neuralgia since the age of fourteen The oldest was ninety four years of age

AGE DISTRIBUTION OF CASES

Age	*Number*
24 29	10
30 39	36
40 49	105
50 59	189
60 69	205
70 79	96
80 89	13
90 94	2
TOTAL	656

Sex Incidence The ratio of females to males was approximately 4 3 (females 58 per cent males 42 per cent) corresponding closely to other large series of trigeminal patients

Side and Division Affected The right side was involved in a

significantly greater number of patients 62 per cent as against 38 per cent with left sided pain

In compiling figures as to the divisions affected, we have included not only the primary pain but also secondary radiation Analysis of the figures indicates that the first division, alone or in combination with other divisions was involved in 215 patients, or 37 per cent We realize that this is a higher percentage of ophthalmic involvement than given by most statistics and for this we have no explanation In 63 per cent of the group the first division was not involved and in these differential section sparing sensation to the cornea was possible

Division Involved	*Number*	*Per Cent*
1st only	23	3.5%
2nd only	67	10.3
3rd only	130	20.0
1st and 2nd	89	13.5
1st and 3rd	4	0.6
1st 2nd and 3rd	129	19.6
2nd and 3rd	214	32.5
TOTAL	656	100.0%

Bilateral Trigeminal Neuralgia At the time of operation five patients gave a history of bilateral pain During the follow up period the incidence of bilateral disease increased so that finally there were thirteen cases or 2.0 per cent of the series with both right and left sided involvement a lower figure than is usually given

Duration of Symptoms The great majority of patients endured the excruciating pain of this disease two or more years before submitting to operation Twenty three per cent suffered ten years or more the longest preoperative history being thirty years

Duration of Symptoms	*Number*	*Per Cent*
Less than one month	3	0.45%
1 – 2 months	13	2.0
3 – 5	28	4.3
6 – 11	34	5.25
12 – 23	42	6.4
2 – 4 years	187	28.5
5 – 9	190	29.0
Over 10	159	24.1
TOTAL	656	100.0%

Trigger Areas and Mechanisms which Induced Pain Three hundred and eighteen patients gave information as to the presence of trigger areas In addition pain was often induced by various external stimuli without reference to a specific region Eating was the most common mechanism producing an attack in 62 per cent washing or shaving the face started an attack in 36 per cent Other external factors such as a wind blowing across the face or sudden changes in temperature were mentioned by 22 per cent In some patients several mechanisms were present con currently

An actual trigger area was found in 56 per cent of the entire series in 52 per cent of the cases involving the second division and in 29 per cent of those with third division neuralgia First division trigger areas present in 6 per cent of that group were the eyebrow forehead and hair The areas commonly affected in the second division were the nasolabial fold the cheek and the upper gum in the third division the lower lip gum and more rarely the tongue The remaining 13 per cent had multiple trigger areas implicating various combinations for two or all three divisions

Operative Statistics Of the 710 operations for trigeminal neuralgia 682 or 96 per cent were carried out under local anaesthesia with 1 per cent procaine hydrochloride In a few instances the operation was begun under local anaesthesia but because of the patient s reactions opiates in high dosage were given intravenously to allay restlessness These cases have been classified as having a combination of local and general anaesthesia Only eight operations were carried out under general anaesthesia when for one reason or another it was thought that a local anaesthetic would be undesirable

During the operation a marked fall in blood pressure occurred in nineteen patients or 2 7 per cent independent of blood loss probably related to the upright position the preoperative medica tion or possibly afferent impulses associated with manipulation of the trigeminal complex In any event it was necessary to lower the patient s back and head following which the operation was completed after a short delay The six complications leading to death will be discussed in the section on mortality

Type of Posterior Root Section. The types of posterior root section performed were as follows:

	Number	Per Cent
Total Posterior Root Section	278	42.4%
Differential Sections		
3rd Division	112	17.0
2nd Division	14	2.0
1st Division	15	2.3
1st and 2nd Divisions	17	2.6
1st and 3rd Divisions	3	0.5
2nd and 3rd Divisions	217	33.2
TOTAL	656	100.0%

These figures represent the primary procedures on 656 patients with true trigeminal neuralgia. Twenty-two or 6 per cent of these experienced recurrence of pain in a different division and in 25 or 7 per cent pain reappeared in the same division. Forty-four reoperations upon the dorsal root were performed. Nine additional *differential* sections were done on the opposite side for bilateral trigeminal neuralgia and one total section was performed for a similar reason. Thus 710 posterior root sections were done for major trigeminal neuralgia: 217 (30 per cent) were subtotal, 189 (27 per cent) were differential sections and 304 (43 per cent) were total sections. In patients of advanced age total resections were done in order to avoid the spread of pain into the ophthalmic division at a time when a second operation would be hazardous as well as psychologically undesirable.

In twenty cases the operator was not completely satisfied that all of the fibers of a given division were sectioned at the time of closure. When doubt as to this point existed, the areas were checked during the operation but the patients' responses were not always reliable. In seven of the patients a second stage procedure was carried out within one week of the first. In the remaining thirteen, the postoperative anaesthesia was deemed sufficiently extensive to afford relief of pain and no further section was carried out. It is of interest, however, that three or 23 per cent of this group experienced a renewal of pain at a later date and are included among those with recurrence.

Postoperative Complications. Temporary facial weakness de-

veloped in 7 8 per cent of all cases appearing between the first and fourth days and occasionally as late as the seventh day after operation and disappearing completely in all but seven patients In these seven or 0 98 per cent there was some residual facial weakness though not of sufficient severity to be disfiguring In no instance was there a complete permanent facial paralysis At the first sign of facial weakness appropriate measures for its correction were instituted (see p 202)

In spite of prompt closure of the eye in every case of facial weakness with corneal analgesia keratitis developed in seven patients or 0 98 per cent Some permanent diminution of visual acuity resulted in 2 or 0 028 per cent In no case in the series was enucleation required Serious ocular complications can be kept to a minimum if care of the eye is promptly taken

Two *postoperative epidural hematomas* were evacuated completely on opening of the wound Four superficial wound infections were handled by local measures subsiding without consequence Nine patients suffered hemiparesis after surgery These were sclerotic subjects in whom a friable dura was torn making exposure difficult and prolonged All but one were sixty years of age or older The single exception a forty two year old man had moderately severe hypertension Complete functional recovery took place in all with the exception of a slight hesitancy in speech in one and an insignificant upper extremity weakness in another All were discharged from the hospital within three weeks after operation Several of these patients maintained a unilateral hyperreflexia as the only residual with no motor impairment In one patient a complete homonymous hemianopsia was found after operation and another had a single generalized seizure on the fourth postoperative day and none thereafter

Herpes simplex was noted in 101 patients Had it been searched for as Carton (1953) recommended the incidence would undoubtedly have been found to be much higher According to his statistics if the palate and buccal membranes were inspected as well as the face herpes simplex would be found in 97 per cent of persons undergoing dorsal root sections

Mortality In considering our mortality statistics it may be repeated that there was no selection of cases according to age or

physical fitness In the series of 710 operations for trigeminal neuralgia 110 patients (17 per cent) were between the ages of seventy and ninety years Patients were operated upon with advanced arteriosclerosis renal disease coronary insufficiency, or hemiplegia alone or in combination

The dangers inherent in the upright position can be minimized by raising the lower extremities to approximate the cardiac level and wrapping them with elastic bandages Unfortunately this was not done in the earlier cases Experience has also taught us to have ready in the syringe appropriate drugs to combat sudden fall in blood pressure or respiratory or cardiac difficulties Had this been done possibly one or two deaths might have been avoided

In addition to the 710 operations for trigeminal neuralgia eighteen posterior root sections as pointed out earlier were done for multiple sclerosis tumors etc making a total of 728 sections Six deaths occurred in the entire series a mortality rate of 0 82 per cent The youngest patient in this group was fifty seven and the oldest seventy three the average age was sixty five One patient had a hemiparesis and in two there was advanced arterio sclerosis The physical status of the remaining three was com mensurate with their age Two patients died in the operating room of cardiovascular complications during the procedure There were three deaths from non surgical causes one on the first one on the seventh and one on the ninth day One patient died on the eleventh postoperative day as a result of injury to the internal carotid artery or the cavernous sinus during operation Brief reports of the six fatalities follow

M H a fifty seven year-old woman with known pulmonary tuberculosis chronic bronchiectasis and generalized arterio sclerosis was admitted to the Neurological Institute of New York on August 14 1930 for trigeminal neuralgia of eighteen months duration in the left third division

Operation On August 27 1930 under 1 per cent procaine hydrochloride local anaesthesia posterior root section was car ried out in the upright position Preliminary medication con sisted of sodium phenobarbital 0 1 gm given one and a half hours prior to operation and morphine sulphate 0 01 gm a

half hour preoperatively. The operation at first proceeded smoothly, the patient receiving 100 c.c. of intravenous saline. During section of the third division fibers, however, a sudden marked drop in blood pressure took place, and shortly thereafter, as the wound was being rapidly closed, respiration ceased. The patient was placed in a horizontal position, artificial respiration was begun, and intracardiac epinephrine given. In spite of all efforts she died in the operating room. At autopsy no cause of death could be determined.

C. I., a fifty-seven-year-old male, was admitted to the Neurological Institute of New York on April 14, 1931, because of trigeminal neuralgia involving the left third division, of eight years duration. The general physical and neurolgical work-up was negative.

Operation. On April 21, 1931, under local anaesthesia, a posterior root section was performed in the upright position. Preliminary medication consisted of sodium phenobarbital 0.1 gm. and Medinal 0.75 gm. one hour preoperatively. Morphine sulphate 0.01 gm. was given on entrance into the operating room.

The patient was anxious and strained a good deal during the early part of the procedure. The dura was adherent and was separated with difficulty, necessitating an intradural approach to the gasserian ganglion. Difficulty was also experienced in maintaining an adequate airway, resulting in increased venous pressure and excessive bleeding, and requiring the insertion of a pharyngeal cannula. Consciousness was suddenly lost, and during closing a right-sided convulsive seizure occurred. Five hundred cubic centimeters of saline had been given intravenously and 0.5 gm. of caffeine sodium benzoate intramuscularly in the course of the procedure.

Course. During the immediate postoperative period the patient did not respond favorably. A progressive right hemiplegia developed. He expired on the first postoperative day. No autopsy was permitted.

P. B., a seventy-one-year-old arteriosclerotic male, was admitted to the Neurological Institute of New York on March 31, 1932, for severe right-sided trigeminal neuralgia in the second and third divisions, of two and a half years duration.

Thirty eight years prior to admission he had first experienced difficulty in walking involving the left side On examination a mild left hemiplegia and hemihypesthesia were found Blood and spinal fluid studies were negative but roentgenograms of the skull and chest showed evidence of Paget s disease and advanced arteriosclerosis

Operation On April 11 1932 under local anesthesia the right posterior root was totally sectioned Preoperative medication consisted of sodium phenobarbital 0 1 gm two hours and again one hour preoperatively Morphine 0 01 gm was given a half hour preoperatively The operation went smoothly the dorsal root being sectioned in thirty five minutes

Course While the patient tolerated the operative procedure well urinary retention and bronchial pneumonia developed on the second postoperative day Cardiac failure ensued with death on the seventh day No autopsy was permitted

H W a seventy three year old woman was admitted to the Neurological Institute of New York for severe right sided trigeminal neuralgia of two years duration Her general physical condition was commensurate with her age

Operation On July 12 1935 under local anesthesia a complete posterior root section was carried out on the right side in the upright position Preoperative medication consisted of sodium phenobarbital 0 1 gm and Medinal 0 3 gm given one and a half hours before surgery Morphine sulphate 0 01 gm was given in the operating room

No technical difficulties arose during the operation and in the early part of the precedure the patient s condition was good As the operator was exposing the ganglion and posterior root venous pressure rose rapidly in association with respiratory and cardiac embarrassment Stimulants were given the root was rapidly sectioned and the wound closed the procedure being completed with the patient in a supine position She seemed then to improve slightly but after transfer from the operating table respiration again became labored cyanosis developed and death ensued shortly thereafter No autopsy was permitted

The root section was complete in spite of the fact that the patient was in poor condition In retrospect it was felt by the surgeon that the operation should have been terminated without attempting to section the dorsal root

D L a sixty year-old woman was admitted to the Neurological Institute of New York on November 12 1949 for recurrent left trigeminal neuralgia involving the left second division She had experienced complete relief for eight years following earlier *differential section* of the second division (May 1 1939) with a minimum of sensory loss Pain then recurred not only in the second division but also in the first The general physical condition was excellent

Operation On November 14 1949 under local anesthesia the previous incision was reopened the patient having been given Demerol 100 mg and scopolamine 0.0004 gm forty five minutes preoperatively The operation went uneventfully until final attempts were being made to sever a few fibers of the first division which clung to the roof and side of Meckel's cave The operator noted bulging in what appeared to be part of the ganglion and brisk bleeding took place It was necessary to pack the area with oxidized cellulose cotton Moderate pressure was applied *locally with simultaneous pressure on the* internal carotid artery in the neck The bleeding stopped and the wound was closed in the usual manner including the insertion of a drain

The patient had been somewhat confused during the height of the bleeding but at the completion of the operation was conscious cooperative and moving all extremities

Course Except for a complete left ophthalmoplegia the immediate postoperative *course* was *surprisingly smooth* The morning of the fifth day however spastic right hemiplegia and complete aphasia developed The wound was reopened and the absorbable cotton cautiously removed Brisk bleeding again occurred in the same region but was easily controlled with a small amount of packing The patient remained alert though aphasic There was some drainage of cerebral spinal fluid from the wound which ceased after the drain was removed on the *second day There was no further improvement* the patient became gradually less alert and died on the eleventh postoperative day Autopsy was not permitted and the source of the bleeding was never ascertained *whether the cavernous sinus* or the internal carotid artery

F K a seventy-one year old man was admitted to the Neurological Institute of New York on April 5 1953 with a diagnosis

of right trigeminal neuralgia His blood pressure was 190/110 the heart was slightly enlarged to the left with marked peripheral arteriosclerosis and there was some pulmonary emphysema

Operation On April 5 1933 under local anesthesia a total posterior root section was done the patient having been given morphine sulphate 0 01 gm and scopolamine 0001 gm forty five minutes preoperatively The operation was uneventful the entire procedure taking fifty minutes during which time the patient received 400 c c of intravenous saline

Course The postoperative course was smooth except for the development of a partial facial weakness on the third day Otherwise progress was satisfactory until the ninth postoperative day when the patient awoke feeling poorly By noon he was perspiring profusely and complained of a sense of impending doom At one o clock he suddenly lost consciousness and both pupils became fixed and dilated He failed to respond to treatment and died at 11 P M The cause of death was considered to be cardiac failure No autopsy was permitted

Long Term Results During the thirty year period covered by this survey many patients had died consequently adequate follow up was not possible We were also hampered in this objective by the ease with which patients and families disappear in a large metropolitan area such as New York

Long term follow up information was available on 355 or 54 per cent of the 656 patients having trigeminal neuralgia Information was obtained either from the patient or if the patient had died from a member of the immediate family who had resided with the patient Only if there had been freedom from pain for at least eighteen months following operation was permanent relief considered to have been achieved Data as to the presence of paraesthesia was accepted as valid if obtained from the patient or from the family a statement as to the absence of paraesthesias however was accepted only if given by the patient himself

Complete relief by either total or differential section in the division originally involved was achieved in 93 per cent of those operated upon Relief of pain was complete and permanent in 303 of the 355 patients from whom adequate follow up data

was obtained or 87 per cent There was recurrence of pain in forty seven patients In twenty five or 7 per cent the recurrent pain was in the *same* division for which the operation was originally performed twenty two or 6 per cent had pain in a *different* division

The details as to the recurrence of pain are as follows

Time of Recurrence	*Original Division*	*Different Division*
Under 12 months	15	1
12 to 23 months	1	3
24 to 35 months	3	4
36 months and over	[illegible]	14
TOTAL	25	22

Alcohol injections were performed on two patients both having previously had a differential section of third division fibers in the dorsal root with the subsequent appearance of pain in the second division which was then blocked One patient with a previous subtotal section of second and third fibers underwent avulsion of the supraorbital nerve for first division pain In three patients the same division fibers which had been previously sectioned or partially sectioned were again divided In sixteen patients because of pain appearing in new areas additional fibers were sectioned in the remaining twenty five a total posterior root section was performed

TYPE OF TREATMENT FOR RECURRENT PAIN

Alcohol injection	2
Peripheral avulsion	1
Differential section	19
Total section	25
TOTAL	47

The time required for reappearance of the pain was as follows

Time of Recurrence	*Original Division*	*Different Division*
Under 12 months	15	1
12 to 23 months	1	3
24 to 35 months	3	4
36 months and over	6	14
TOTAL	25	22

Postoperative Status In 87 per cent of 656 patients operated upon for trigeminal neuralgia no postoperative complications arose This number does not include those operated upon for recurrent trigeminal neuralgia or for multiple sclerosis atypical facial pain etc Including these 728 dorsal root sections were done and of this total 602 or 82 per cent presented no post operative complaints

Paraesthesia Information concerning the occurrence of paraesthesias was obtained in 42 per cent of the patients who were followed for eighteen months or more Of these 61 per cent stated that paraesthesias were of no consequence 29 per cent were mildly disturbed by these sensations The remaining 10 per cent were severely disturbed by paraesthesias which they described as creeping burning itching etc There was no apparent correlation between the type of operation carried out and the appearance of paraesthesias nor was there any significant relationship between the age of the patient and the appearance of these complaints Previous alcohol injections did not seem to play any role

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